

UNIVERSITY OF BRISTOL



THE ANNUAL REPORT

OF THE

Agricultural and Horticultural
Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL
1941

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INTRODUCTION.

By **B. T. P. BARKER, M.A.,** Director.

War-time conditions and their attendant problems have continued to dominate the policy and work of the Department of Agriculture and Horticulture throughout the period covered by the present Annual Report. The Department as a whole has been obliged to make further modifications in its programme of work and adjustments in its working arrangements to meet current requirements.

At each of the three Departmental Centres, at Bristol, Campden, and Long Ashton respectively, the services of the staffs have been in further increasing demand in various directions of National Service in administrative, advisory and research capacities. Provision for necessary staff additions in some Sections has been made by increased Government grants.

A notable development during the year has been the establishment of a Field Laboratory at Evesham, which has enabled very close contact to be maintained with the important market garden industry in that district. It has been made possible by the loan of a temporary building by the Agricultural Research Council. Two members of the staff of the Department are stationed permanently at the laboratory as their headquarters, while other members of staff, when engaged on duties in that region of the Bristol Province, find a local centre of this nature very useful.

For details of the year's work at Campden reference should be made to the Annual Report of that Research Station, now issued separately. Continued and generous financial support in increasing amount from the canning industry has been received in aid of the work.

A continuation of the improvement in the financial position begun in the previous year can be recorded also for the Centres at Bristol and Long Ashton. In the case of the latter Station this satisfactory result is attributable largely to the returns from vegetable crops, which more than counterbalanced the loss of income due to the partial failures of the fruit crops caused by late spring frosts.

The Department has to report with deep regret the serious losses sustained by the deaths of Emeritus Professor F. E. Francis and Alderman Henry Matthews, two of the senior members of the Committee. Both had been continuously associated in that capacity with the Department from the time of its establishment in 1912, when the National Fruit and Cider Institute became an associated institution of the University. Throughout this long period their continued interest in its work and their active help and advice on matters touching its welfare and development have been invaluable.

BRISTOL AGRICULTURAL ADVISORY CENTRE.

Staff.

Changes in personnel during the year have been confined mainly to junior members. Details are given in later pages of this publication in the Report on Advisory Work, 1940-41.

Buildings.

In consequence of the continuous expansion of work the accommodation at Berkeley Square has been strained increasingly for several years and has proved entirely inadequate to meet the requirements for space which the past year has imposed. Temporary arrangements for the use of a room in the Long Ashton laboratory building were made as an emergency measure for the new Farm Survey Scheme while other quarters more conveniently situated for the Bristol workers were being sought. It is expected that other premises in Bristol will be placed at the disposal of the Centre by the University at an early date to relieve the congestion at Berkeley Square.

LONG ASHTON RESEARCH STATION.

Staff.

Apart from temporary changes enforced by the departure of junior members of the recording and office staffs for service in the Forces and by the need for additional help in the Fruit Products and Domestic Preservation Sections, the staff remained unaltered throughout 1941. Reference is made to the individual cases concerned in the list of staff changes given in the Report on Advisory Work, 1940-41.

Buildings and Land.

No building extension having been possible during the year, the demands on available space have become severe and have had to be met by temporary expedients. The urgent need for additional accommodation for the increased number of workers in the Domestic Preservation Section has resulted in the sanction of a small grant by the Ministry of Agriculture and Fisheries for the adaptation of a wooden Army Hut, erected for storage purposes during the last war, to serve as a Home Kitchen for experimental and instructional work.

In the plantations and nurseries of the Station the considerable modifications in the programme of work referred to in last year's Report have been still further extended so as to give the utmost attention to special war-time problems. In particular, long-period research projects on fruit growing with little likelihood of immediate practical application have been suspended. Where possible without undue interference with the fruit research programme, field plots on the Station farm previously planted with fruit have been cleared so that the land may be used for experiments on vegetable culture. As a result, approximately 30 acres of land at the Station are now under vegetable crops. The main innovation in this development of the field work has been the initiation of manurial experiments on the more important vegetable crops. Further plots for this purpose have also been established in the Vale of Evesham and at other scattered centres. The primary aims of these experiments are to examine the special manurial requirements of the vegetables of importance under war-time conditions and to ascertain the best means of maintenance of the crops under present conditions of shortage of supplies of organic manures and artificial fertilisers. In order to ascertain to what extent the special treatment applied may affect the incidence of diseases and pests and the nature of the control treatment required, these experiments are linked up with the work on vegetable pathology carried out by the Pathological Section of the Station.

In addition to these changes in the nature of the field work at Long

Ashton, other portions of the farm previously under grass have been ploughed and used for the production of agricultural crops. During the autumn a further Order to plough another 33 acres of hillside grass, previously used for live-stock grazing, has necessitated a drastic change in policy respecting the whole of the farm land at the Station other than that already reserved for fruit and vegetable crops. The new arrangements now being effected will be reported upon when completed.

Although high explosive and incendiary bombs have been dropped on land at the Station during the year and have caused damage on some of the experimental plots, the buildings have suffered but slight damage.

Research Activities.

In the following pages of the Report details of some of the investigations carried out at this Station in 1941 will be found. Certain other researches have also been undertaken, although at this stage publication in their case has been deferred.

In the Fruit Products Section important work has been in progress throughout the year. Many special problems in which the Ministries of Agriculture, Food and Health are all concerned, have been undertaken at the request of those bodies. Valuable results have already been obtained in several directions and some of the resultant products, such as black currant syrup and rose hip syrup, have been taken up for commercial production on account of their value as sources of Vitamin C. In view of the prospective heavy crops of carrots, investigations on products from this vegetable have been made and, from a part of the surplus material available, processing will be started soon on a large scale for food supply purposes.

Both this Section and the Entomological Section have rendered valuable services to the Public Health Authorities in Bristol, in connection with the salvage of foodstuffs and public health problems, which arose in consequence of the intensive air raids in Bristol during the winter of 1940-41.

The Section concerned with the Domestic Preservation of Fruit and Vegetables has worked in close collaboration with the Ministries of Agriculture and Food in connection with official schemes for preserving garden produce.

General.

Annual Field Day. In accordance with the general war-time policy of the Station to concentrate as far as possible on activities concerned with the national emergency, functions such as the Annual Tasting Day have been suspended. The Annual Meeting of the Members of the National Fruit and Cider Institute held at the Station on Friday, June 27th, afforded, however, an opportunity for subscribers to the Institute to view the more recent developments of the work in progress.

An additional occasion enabling subscribers to keep in touch with current work at Long Ashton was provided on Thursday, September 25th, by a demonstration of a simple method of prolonging the storage life of apples by the use of the new Ditton Apple Dip. The process was described and shown by Mr. C. R. Furlong, a member of the staff of the Ditton Laboratory of the Food Investigation Board. On this occasion the Institute was thrown open to fruit growers and the general public as well as to subscribers.

Visitors. The prevailing conditions have continued to check the number of individual visitors coming to the Station for a general inspection of the work. On the other hand they have tended to increase the number of personal visits paid by enquirers seeking advice on problems concerned with food production and by those directly or indirectly interested in one or other of the numerous war emergency schemes with which the Station is associated.

Fewer organised parties of visitors have been received during the year. Owing to transport difficulties these have been drawn only from Bristol or the near neighbourhood. The list is as follows:—

King's College (London) Engineering Society.
King's College (London) and Bristol University Botanical Societies.
Patchway Gardens Guild.
Bristol Pharmaceutical Society.
Bristol Section of Royal College of Nursing.
Jacob Street, Bristol, National Fire Service Station.
Cultivators of "Growmore" Demonstration Plots.
Ashton Youth Service.

Shows. Although hitherto during the war period general exhibits at various shows have been suspended, small exhibits appropriate to the "Dig for Victory" campaign have been sent by special request of the authorities concerned to the following shows:—

Cheltenham Horticultural Exhibition.
Gloucester Food Production Show.
Bath "Dig for Victory" Exhibition.

Research Students and Voluntary Workers. There have been no post-graduate students pursuing research for higher degrees at the Station during the year, the flow of such students having been stopped by the war. One voluntary research worker, Mr. A. F. Parker-Rhodes, B.A., Dip.Agr., has continued, however, the investigations on the mode of action of fungicides on which he had been engaged during the previous year.

Much useful help in the practical and recording sides of the work in the fruit plantations has been given by Mr. J. E. Beviss as a voluntary worker. During the months of August and September parties of scholars from the Clifton High School for Girls, the Red Maids School, Bristol, and the Long Ashton School as well as Girl Guides from West Bristol, gave valuable assistance in the harvesting of fruit and vegetable crops at the Station.

Acknowledgments.

The Department desires to record its warm appreciation of the ready assistance which it has continued to receive from growers, industrial firms and other organisations and individuals in the course of its operations during the year. Despite the many difficulties under which such help and collaboration have been given there has been a generous measure of support wherever needed and the progress achieved has been largely attributable to it.

To the staff of all grades in the Department acknowledgment is due for the manner in which they have carried out their duties, often under circumstances of considerable personal discouragement and difficulty.

A TRIAL OF CIDER APPLE VARIETIES GROWN AS BUSH TREES UPON CRAB AND VEGETATIVELY RAISED ROOTSTOCKS.

PROGRESS REPORT 1935—1941.

By THOMAS SWARBRICK.

Introduction.

This report deals with one section of the investigations started at Long Ashton in 1930-1931, to examine the possibilities of producing cider apples under conditions similar to those employed in the production of culinary and dessert fruit.

The investigations embrace two main experiments. For the first, trees are planted at Long Ashton, consisting of three varieties on two rootstocks and with two different lengths of main stem. The second, of which this is a progress report covering the first five years, is a trial of selected varieties on crab and Malling No. 1 rootstocks planted at a number of centres in cider and commercial fruit growing areas.

All trees were propagated in the Research Station nurseries. The crab stocks used were commercial French seedling crabs, such as would normally be used for raising commercial standard apple trees. Malling No. 1 stock was chosen as being of medium vigorous habit with a good root system. The trees were budded in July, 1932, headed at approximately two and a half feet high and were three year old trees with two year heads ready for planting out in winter 1935-1936.

The varieties used were mainly high quality bitter-sweets with a few sweet and mild sharp varieties of outstanding vintage quality. The centres were chosen so as to include all the principal cider apple producing areas and the important apple producing county of Kent. They were also chosen with particular reference to the soil types which are available in the various areas. With the one exception of the centre at Bere Alston, which is owned and run by the Devon County Council, all the plots were established on farms owned or farmed by cider manufacturers or commercial fruit growers. The trees were supplied and delivered by the Research Station during autumn 1935, and any replants required to replace damaged trees were supplied during winter 1936-37.

The growers have undertaken to co-operate fully as regards planting distances, arrangement of the plots and general management, and the Research Station is also to be provided with facilities for all records etc., that may be required from time to time.

The Centres.

The following is a brief description of the eight centres.

Centre I. Hereford.

This is situated just outside the City of Hereford, on land previously used as a nursery. The site is practically level. The soil is a fine sandy

loam, mainly derived from Old Red Sandstone, with admixture of Welsh drift. The varieties planted are Foxwhelp, Sweet Alford, Kingston Black, Broad Leaf Norman, Yarlington Mill, Bulmer's Norman, Perthyre, White Jersey, Dabinett, White Close Pippin, Medaille d'Or, Sherrington Norman, Ellis Bitter, Silver Cup, Royal Wilding, Michelin, Reine de Pomme, Tardive Forestier, Knotted Kernel.

The ground is cultivated in the alleyways, part of the plot being used for the production of special clover and grass seeds, the remainder for potatoes etc. Pruning and general management are good.

Centre II. Newnham Bridge, Worcestershire.

This is situated just out of Newnham Bridge on land which has been farmed as arable. The site is a gentle slope facing west, and forms part of a small knoll. There is a small stream at the bottom of the slope, a short distance below the site. The soil varies in passing down the slope, the upper portion being a heavy, fine sandy loam derived from Old Red Sandstone Marl and the lower portion being deeper with the surface soil modified by a varying amount of alluvium, mainly of Old Red Sandstone origin. An adjoining field is planted with standard cider apples under the Long Ashton Trial Scheme for Standard Trees. These latter trees are now about 20 years old. Many varieties are common to both trials.

The varieties planted at this centre are Kingston Black, Perthyre, Yarlington Mill, Woodbine, White Close Pippin, Red Jersey, Sweet Alford, Reine de Pomme, Dabinett, Broad Leaf Norman, Reinette Obry, Ellis Bitter, Tardive Forestier, Stoke Red, Royal Wilding, Bulmer's Norman, Frederick, Foxwhelp, Slack-ma-Girdle, Knotted Kernel and Medaille d'Or.

The trees are maintained under cultivated conditions, the alleyways being used for growing potatoes, swedes, mangolds, etc. General management is good. Pruning was rather hard for the first few years, but is now much less drastic. The growth of these trees is very vigorous.

Centre III. Much Marcle, Herefordshire.

This site occupies an elevated position on the slope of a small hill facing east, but is not unduly exposed. It is in the middle of an area where large quantities of cider apple trees are grown in grass orchards, the area being perhaps more famed for its perry pear trees, which make very large trees. The soil is a fine sandy silty loam, typical of those derived from Silurian Mudstone. The depth is variable but is mainly shallow with mudstone rock at 1' to 2' 6" depth.

The varieties planted are, White Jersey, Foxwhelp, Sweet Alford, Broad Leaf Norman, Perthyre, Dabinett, Silver Cup, White Close Pippin, Bulmer's Norman, Ellis Bitter, Knotted Kernel, Tardive Forestier, Reinette Obry, Dymock Red, Reine de Pomme, Stoke Red, Frederick, Slack-ma-Girdle, White Norman, Dove, and London Red.

The trees are grown under cultivated conditions, the alleyways being used for potatoes, mangolds, etc. Management is good, although a certain amount of stem damage is evident. Tree growth is very satisfactory.

Centre IV. Poundisford, Somerset.

The site is a level, but elevated, piece of land which has been used for

arable farming. The remainder of the field—about 4 acres—has been planted by the owner with dessert varieties, mainly Ellison's Orange, Cox, Superb, etc., so that an excellent comparison will be afforded.

The soil is a fine sandy medium loam, mainly derived from Keuper Marl, but contaminated with surface wash—"Head"—containing material including cherts of Greensand origin.

The varieties planted are Kingston Black, London Red, Slack-ma-Girdle, Woodbine, Frederick, Dymock Red, Stoke Red, Reine de Pomme, Knotted Kernel, Tardive Forestier, Bulmer's Norman, Michelin, Silver Cup, Perthyre, Medaille d'Or, Broad Leaf Norman, Sweet Alford, Yarlington Mill and Dabinett.

The trees are maintained in cultivated conditions, the alleyways being used for potatoes, mangolds, etc. The general management is good and the trees are making most satisfactory growth.

Centre V. Whimble, Devon.

This site is slightly elevated, with a gentle slope towards the west. In recent years extensive plantings of standard cider apple trees have been made in the immediate area. The adjoining field was planted only a few years prior to the establishment of this trial. The soil is mainly derived from New Red Marl, the lower part of the site being covered with a depth of colluvial marl material. The raw marl occurs at a depth of 15" to 18" near the top of the slope. The soil texture is generally a heavy, fine sandy, silty loam.

The varieties planted are Yarlington Mill, Silver Cup, Bulmer's Norman, Dabinett, Ellis Bitter, Kingston Black, Tardive Forestier, Sweet Alford, Foxwhelp, Reine de Pomme, Cap of Liberty, Dove, Knotted Kernel, Broad Leaf Norman, Star of Devon, Fair Maid of Devon, Medaille d'Or, Stoke Red, Perthyre, Frederick.

The soil of this site lies rather heavy and wet in winter and great difficulty was experienced in planting the trees. Unfortunately a number of trees died and had to be replaced; the remainder, however, have made excellent growth. The trees are maintained under cultivated conditions, the alleyways being used for mangolds, potatoes, etc. Many trees, particularly those on the outside rows, have been damaged during cultivations. Pruning is satisfactory and the growth of the trees good.

Centre VI. Compton Greenfield, Gloucestershire.

This centre is on the Gloucester side of Bristol, on land facing the Severn Estuary. The site is near the bottom of a gentle slope which passes into a flat low-lying plain. The land has been used as arable for a number of years. The soil is mainly formed from colluvial Keuper Marl and is a medium to heavy, fine sandy, silty loam. The profile to a depth of 2' shows signs of drainage impedence.

The varieties planted are Bulmer's Norman, Sweet Alford, Foxwhelp, Dabinett, Yarlington Mill, Broad Leaf Norman, Chisel Jersey, Medaille d'Or, Perthyre, White Close Pippin, Royal Wilding, Knotted Kernel, Reine de Pomme, Dymock Red, Reinette Obry, Stoke Red, Frederick, Ellis Bitter, Woodbine and Cap of Liberty.

The general management is good and the trees have made excellent growth.

Centre VII. Faversham, Kent.

The site occupies a level piece of land of a type used for fruit and hop growing in this area. It adjoins a hop yard and other commercial fruit orchards growing in this area. The soil is a fine sandy, medium loam containing flints, derived mainly from a shallow Brick Earth deposit overlying Chalk.

The varieties planted are Tardive Forestier, Foxwhelp, Silver Cup, Ellis Bitter, Kingston Black, Perthyre, Broad Leaf Norman, Reine de Pomme, Royal Wilding, Sherrington Norman, Yarlinton Mill, Knotted Kernel, Medaille d'Or, Chisel Jersey, Bulmer's Norman, Dabinett, Sweet Alford.

The trees at this centre suffered rather severely from rabbit and hare damage during their first winter and some trees had to be replaced. In spite of this, however, they have made excellent growth and now are amongst the best trees in the trial.

Centre VIII. Bere Alston, Devon.

This centre is on land occupied by the Devon County Council and used as a trial ground. It is situated some little distance out of Tavistock. The site forms the south-western corner of a typical knoll of the area and from it large stretches of the valley below are visible. Although relatively high, the exposure to wind is not so severe as might be expected, but wind damage is undoubtedly a factor of importance on this site. The soil is rather thin and poor, overlying shale, known locally as "shillet," and in spite of heavy applications of potash there is a strong tendency to leaf scorch. The general growth conditions, as regards soil and climate, are undoubtedly the least favourable of the several centres under review.

The varieties planted are Sweet Alford, Bulmer's Norman, White Close Pippin, Ellis Bitter, Broad Leaf Norman.

Management is satisfactory and considering the poor conditions—which of course are typical of many Devon cider orchard sites—the trees have, with one outstanding exception, made fairly satisfactory growth. This exception is Broad Leaf Norman, which has suffered very severely from canker, so much so that the trees are worthless.

Each of the first seven main trial centres, as initially planned, comprised two hundred trees made up of ten trees of each of twenty varieties. Of these ten trees five were on crab and five on the rootstock M.I. Since growers expressed preferences for, and prejudices against, certain varieties the number of varieties common to most centres was reduced to thirteen. Several other varieties occur at four centres only but the present comparison is based upon the varieties occurring at most of the centres.

Records, Season 1941.

During the early autumn of 1941 a tour was made of the centres with the object of measuring tree size and taking notes on general tree conditions, cropping, etc. The following brief report is based upon the data obtained from the measurement of height, spread and girth of every tree.

A summary of the mean height, spread and girth of the several varieties

at the eight centres is given in Table I. This is a summary table only and does not show the variation in tree size as between the centres. Some idea of this variation may be obtained from a study of Table II, which gives the mean height, spread and girth of the Sweet Alford trees at the individual centres. The range of individual tree variation is shown in Table III which gives the actual measurements of the ten Sweet Alford trees at Whimple.

I. *Varieties in relation to tree size and cropping.*

Table I shows that certain varieties are small, others large. The large varieties are Perthyre, Broad Leaf Norman (except at Bere Alston), Sweet Alford, Bulmer's Norman and Ellis Bitter. The smallest sorts are Dabinette and Medaille d'Or. The variety Silver Cup is characteristically very upright in habit with a number of rather weak thin shoots bearing small foliage.

Dabinett is an exceptional variety, being apparently very susceptible to leaf scorch (potash deficiency) at the two centres Faversham and Compton Greenfield, where all other sorts have made vigorous growth and good trees. In fact the smallest trees of Dabinett occur at Faversham which is otherwise one of the best centres. At two other centres where general tree growth is good Dabinett shows a tendency to leaf scorch.

Varietal character is shown most strongly in cropping. The present report covers only the first five years from planting and one of the interesting points of the trial is the fact that certain varieties have already cropped. Dabinett is outstanding in this respect, since at every centre it was carrying a fair crop. An estimate of the crop at one centre was some 20 lb. per tree, or about 1 ton per acre at the planting distance of 20×20 feet. Useful crops have been gathered at most centres—from Perthyre, Sweet Alford and Yarlinton Mill, and lesser crops from Bulmer's Norman, Broad Leaf Norman and Medaille d'Or. The remaining sorts present at most centres have not as yet given any appreciable crop. Although included at only four centres, White Close Pippin is outstanding and is undoubtedly the heaviest cropping variety in these trials. This variety cropped in 1940 at one or two centres and at one centre in 1941 its yield was estimated at 30 cwt. per acre. Kingston Black and Royal Wilding, which are also only planted at four centres, have also cropped fairly well.

II. *The Effect of Rootstock on Tree Size and Cropping.*

The data in Table I show that, whilst the trees on crab are on the average a little larger than those on M.I., the difference so far is not important. The effect of rootstock upon cropping is more noticeable than its effect upon tree size. While no definite figures are available there is no doubt that the trees on M.I. are cropping earlier and more heavily than those on crab. In certain cases, *e.g.* White Close Pippin and Sweet Alford, the difference in favour of trees on M.I. is most noticeable.

III. *Effect of Centre on Tree Size.*

This is shown in Table II which sets out the mean tree size of the variety Sweet Alford at the several centres. The range in size is considerable, varying in height from $14\frac{1}{2}$ to $10\frac{3}{4}$ feet, in spread from 11 to 6 feet, and in girth from $12\frac{1}{2}$ to $7\frac{1}{2}$ inches. This difference in size is due largely to differences in soil conditions, and to a less extent to management. At the Faversham centre

the trees have a much greater spread than elsewhere, due to soil and management. Owing to the encouragement of tree spread at this centre the head volume of the trees has been very much increased as against corresponding trees of this variety at Poundisford, where they are almost the same height but have been kept pruned in so as to allow easy cultivation of the alleyways. It takes little imagination to connect these differences in tree size with potential yield. Mainly due to soil conditions, the Kent trees have nearly twice the cropping capacity of the corresponding varieties at Bere Alston. This difference is likely to persist for many years and may even be widened in favour of the Kent trees.

TABLE I.

SHOWING MEAN HEIGHT, SPREAD AND GIRTH OF FIVE TREES OF EACH VARIETY ON EACH ROOTSTOCK. HEIGHT AND SPREAD IN FEET. GIRTH IN INCHES.

No. of Centres at which variety occurs.	Variety.	Crab.			M.I.		
		Height	Spread	Girth.	Height.	Spread.	Girth.
6	Perthyre	12 $\frac{3}{4}$	8 $\frac{3}{4}$	9 $\frac{1}{2}$	12 $\frac{3}{4}$	9	9 $\frac{1}{2}$
7	Broad Leaf Norman ..	12	7 $\frac{1}{2}$	8 $\frac{3}{4}$	11 $\frac{3}{4}$	7 $\frac{1}{2}$	8 $\frac{1}{2}$
7	Sweet Alford	12 $\frac{1}{2}$	7 $\frac{1}{4}$	9	11 $\frac{1}{4}$	6 $\frac{3}{4}$	8 $\frac{1}{4}$
7	Bulmer's Norman ..	11 $\frac{1}{2}$	8 $\frac{1}{2}$	9 $\frac{3}{4}$	11 $\frac{3}{4}$	8 $\frac{1}{4}$	9 $\frac{3}{4}$
5	Ellis Bitter	12	7 $\frac{1}{4}$	9 $\frac{1}{4}$	11 $\frac{1}{4}$	6 $\frac{3}{4}$	8 $\frac{3}{4}$
5	Reine de Pomme ..	11 $\frac{1}{4}$	7	8	10	6 $\frac{1}{4}$	7 $\frac{1}{4}$
5	Yarlington Mill ..	13	9 $\frac{1}{2}$	9 $\frac{3}{4}$	12	8 $\frac{1}{2}$	9
6	Tardive Forestier ..	12	7 $\frac{1}{2}$	9	11 $\frac{1}{4}$	6	9
6	Foxwhelp	10 $\frac{1}{2}$	7	7 $\frac{3}{4}$	10	6	8 $\frac{1}{2}$
5	Knotted Kernel ..	12	6 $\frac{3}{4}$	9 $\frac{1}{4}$	10 $\frac{3}{4}$	6	8 $\frac{1}{4}$
5	Medaille d'Or	10 $\frac{1}{2}$	6 $\frac{1}{2}$	9	10 $\frac{1}{2}$	6 $\frac{1}{4}$	8 $\frac{3}{4}$
5	Silver Cup	10	6	8	8 $\frac{3}{4}$	5 $\frac{1}{2}$	7
6	Dabinett	9 $\frac{3}{4}$	7 $\frac{1}{4}$	8 $\frac{3}{4}$	8 $\frac{3}{4}$	6 $\frac{3}{4}$	7 $\frac{1}{2}$
4	White Close Pippin ..	10	7 $\frac{1}{4}$	8 $\frac{1}{4}$	9 $\frac{3}{4}$	7	8 $\frac{1}{2}$
4	Stoke Red	10	5 $\frac{3}{4}$	7 $\frac{1}{2}$	10	6	7
4	Frederick	9 $\frac{1}{2}$	5 $\frac{3}{4}$	8	9 $\frac{1}{2}$	5 $\frac{1}{2}$	7 $\frac{1}{2}$
3	Reinette Obry	11	7 $\frac{1}{2}$	10	11	8	10
3	Kingston Black	11	8	9	10 $\frac{1}{2}$	7	8 $\frac{1}{2}$
3	Woodbine	12	6	8	11 $\frac{1}{2}$	5 $\frac{1}{2}$	5
3	Royal Wilding	12	8	9 $\frac{3}{4}$	10	7 $\frac{3}{4}$	9
3	Slack-ma-Girdle ..	11 $\frac{1}{4}$	5 $\frac{1}{4}$	8 $\frac{3}{4}$	11 $\frac{1}{4}$	5 $\frac{1}{4}$	8 $\frac{3}{4}$

TABLE II.

SHOWING THE MEAN HEIGHT, SPREAD AND GIRTH OF THE TREES OF SWEET ALFORD AT THE SEVERAL CENTRES. HEIGHT AND SPREAD IN FEET, GIRTH IN INCHES.

Centre.	Crab.			M.I.		
	Height.	Spread.	Girth.	Height.	Spread.	Girth.
Faversham	14½	11	12	12	9	10
Poundisford	14¼	9½	10	12	8¾	9
Compton Greenfield	13½	7¼	9½	13	7¼	10
Newnham Bridge	13	7	9	13	7¼	8¾
Hereford	10¾	5	7½	10¼	5	7
Bere Alston	10¾	6	7½	9¼	5½	6¾
Much Marcle	11¾	6	9½	11	6	9
Whimple	10¾	6	7½	9¼	5½	6¾
Means all Centres	12½	7¼	9	11¼	6¾	8½

TABLE III.

SHOWING THE INDIVIDUAL TREE SIZES OF THE VARIETY SWEET ALFORD AT WHIMPLE; HEIGHT AND SPREAD IN FEET, GIRTH IN INCHES.

Crab.			M.I.		
Height.	Spread.	Girth.	Height.	Spread.	Girth.
9½	5	7	9½	4½	7¼
9½	4½	5¾	12	5	9
10	5	6½	9½	5	6¾
11	5½	6¾	11	5½	7¼
11	6	8¼	10	5	6¾

Discussion.

The first important point which emerges from this trial is the uniformly satisfactory growth made by the thirteen varieties growing at all of the centres. It has already been pointed out that certain varieties have attained a mean height of about 12½ feet with a mean spread of 8½ feet, or a theoretical head volume of about 100 cubic feet. For five years growth this must be regarded as very satisfactory. It is gratifying to report that of the varieties selected none have been found generally unsatisfactory. The case of Broad Leaf Norman at Bere Alston forms the one interesting case of a variety failure. But since the failure is confined solely to one centre it must be due to environmental or soil factors peculiar to this centre alone. It is well known, of course, that certain varieties do well in one locality while they may be unsatisfactory

in others. Kingston Black, the most famous of all cider varieties, is a case in point. It grows and does well in certain parts of Gloucester and Hereford but it is almost impossible to obtain good trees at Long Ashton and other places due to severe attacks of canker. It is obviously impossible to discuss this point further here, but the development of such a situation as that occurring at Bere Alston was not unexpected and it is surprising that the selected varieties have proved to be so generally successful.

The second important point concerns the effect of rootstock. That the trees have made approximately similar amounts of growth on the two rootstocks is of interest. Moreover, there is nothing to choose between the trees on crab and those on M.I. as regards variability. Both trees on seedling crab and vegetatively raised rootstocks show a wide range in tree size due to a number of causes, of which mechanical damage is of major importance. The effect of rootstock upon cropping appears quite definite. The trees on M.I. are cropping much earlier than those on crab, although certain varieties, *e.g.* Knotted Kernel and Silver Cup, have not cropped even on this rootstock. Other varieties, *e.g.* White Close Pippin, Dabinett, Sweet Alford and Yarlington Mill, are cropping quite well and yields of over one ton per acre were obtained in 1941, which is only the sixth year from planting.

The effect of soil upon tree growth is important. The largest trees occur at the Faversham centre where the soil is a fertile Brick Earth such as is used for hop growing. The management at all centres is satisfactory although at two there is an excessive amount of tractor or other mechanical damage to the trees. It is as yet too early to offer any considered opinion as to the possibilities of this method of cider fruit production, but the evidence available suggests that within the next three or four years most, if not all, the centres should be producing fairly good crops. From a consideration of tree size and growth, crops up to five tons per acre may be expected within a few years. As the less precocious sorts come into bearing this yield will no doubt be exceeded.

Summary.

1. An experiment is described, the object of which is to examine the possibility of growing cider fruit on bush trees under plantation conditions.

For this purpose trial plantations have been established at eight centres in important fruit growing districts. The varieties used comprised a wide selection of vintage sorts, mainly of the Bittersweet class, and the trees at each centre are worked on crab and Malling No. 1 rootstocks.

2. Brief descriptions of the centres are given and the condition of the trees, as regards growth and crops at the end of the first five years of the experiment, are summarised.

3. The following points emerge from the records: the varieties have succeeded under a wide range of conditions and only in one case has a variety proved unsatisfactory; varietal characters, both as regards growth features and precocity are clearly shown; rootstock effect is not so far of great importance as regards tree size but is clearly evident in respect of precocity; tree size shows considerable variation between the various centres, and site, soil and management factors all appear to be of importance; in the fifth year after planting crops of 1 ton per acre were harvested from certain varieties.

THE INFLUENCE OF ALPHA-NAPHTHALENE ACETIC ACID SPRAYS ON THE PRE-HARVEST DROP OF APPLES UNDER DIFFERENT SYSTEMS OF PRUNING.

By W. E. BERRY and T. SWARBRICK.

Introduction.

Amongst the various properties of plant growth substances, the recently-discovered effect on the abscission of apples is of interest. F. E. Gardner, of the U.S. Horticultural Station, Maryland (1), has shown that the dropping of fruits before harvest-time can be considerably reduced by spraying with low concentrations (as small as 1 part per million) of water solutions of naphthalene, acetic acid or naphthalene acetamide. A large number of American varieties of apple have responded to this treatment, the degree of success depending largely on the ease with which the fruit stalk can be wetted. Long-stalked varieties, which retained more spray in the stalk cavity, responded better than short-stalked varieties.

The effectiveness of the sprays reached a maximum five or six days after treatment and continued for two or three weeks. When mixed with routine oil sprays their efficiency was increased rather than diminished.

It is natural to consider the possible applications of growth substances for controlling "fruit drop" in this country. So far, the sprays have proved ineffective in controlling "June drop," which may be a more serious problem in this country than pre-harvest drop. There is little occasion to keep fruits on the trees beyond the time at which they are normally picked, and the loss from dropping before this time is usually not very serious with most varieties.

Vyvyan at East Malling (2) has shown that dropping from the varieties Beauty of Bath, Worcester Pearmain and Cox's Orange Pippin can be reduced by spraying with 5 p.p.m. alpha-naphthalene acetic acid. In the West Country there is always a risk of the crop being blown from the trees if it is not picked before the onset of south-westerly gales in September, and in some cases it would be convenient and economical to be able to reduce fruit drop due to this cause. A case in point is the late-keeping culinary variety King Edward VII, which could with advantage be left on the trees till the end of October but is often picked a month earlier to avoid the risk of September gales.

Material and Methods.

The variety Edward VII is included in a pruning experiment on the Research Station plantations in which six varieties of apple are subjected to five different pruning treatments. The plot, nearly three acres in extent, is laid out in twelve randomised blocks. Five trees of Edward VII occur in each block, each tree receiving a different pruning treatment. The opportunity was thus presented to find the effect of spraying this variety with a growth substance and at the same time to compare the influence of pruning treatment on fruit drop.

The five pruning treatments are as follows :—

1. No pruning apart from removal of crossing branches.
2. Open centre, winter pruned only.
3. Open centre, winter and summer pruned.
4. Modified leader, winter pruned only.
5. Modified leader, winter and summer pruned.

Alpha-naphthalene acetic acid was used as the spray material. This was dissolved in a small quantity of methylated spirit and added to an appropriate volume of water in the spray tank to produce two concentrations of 5 and 10 parts per million respectively. Four blocks, each containing five trees of Edward VII, were chosen to be sprayed with the solution at a strength of 5 parts per million, and four similar blocks at 10 parts per million, leaving four blocks as unsprayed controls.

The Northern half of the plot is on level ground, whilst the southern half rises somewhat and is more exposed to the wind. The treatments were randomised separately on the two halves of the plot, each half thus containing duplicate blocks for each of the three treatments.

The spray was applied on September 19th, using a lance, with a spray pressure of about 200 lbs. Four gallons of spray were applied to each tree and an attempt made to wet the fruit stalks thoroughly.

During the following three weeks the weather was calm and practically no fruit drop occurred either from the treated plots or the controls. As the effect of the spray must by this time have been wearing off, it was decided to spray the trees again. By this time, however, the risk of gales was serious, and it was decided that on economic grounds, the southern half of the plot only should be resprayed and the crop picked from the northern half. Accordingly on October 14th the treatments were repeated on the southern half of the plot, but before the crop could be picked from the northern half, the expected gale occurred and on the morning of the 19th half the crop was on the ground. The gale arose during the night of October 18/19th when the anemometer records showed continuous velocities of 30 m.p.h. for two periods of 3 to 4 hours, with short gusts over 40 m.p.h. The maximum gust recorded was 52 m.p.h.

Counts were made of the numbers of fallen fruits and the numbers left to be picked from each tree. In view of the double amount of spray applied to the southern half of the plot, it was decided to treat the data for the two halves of the plot separately, although the second application had perhaps not had time to produce its maximum effect.

Results.

The percentage numbers of fruits fallen from each tree were calculated and the results analysed statistically. Tables I and II show the data for the two halves of the plot. Five trees in the northern half of the plot and one in the southern half had been replaced with a different variety. These were treated as "missing plots" and the values calculated by the procedure described by Yates (3). The significance of the spray and pruning treatments were determined by calculating the standard errors of the means and the appropriate values of "t."

TABLE I.
FRUIT DROP (PER CENT.)—NORTHERN HALF OF PLOT.

Spray Treatment.	Pruning Treatment.					Mean.
	1	2	3	4	5	
.0005%	46.38 71.80	30.66 40.26	21.62 48.08	47.24 49.68	28.41 } 39.71 }	42.38
.001%	54.05 29.47	26.64 50.00	28.60 24.10	40.38 40.23	22.68 } 21.51 }	33.77
Control	56.57 62.50	48.65 46.70	43.51 50.37	45.23 57.65	30.08 } 45.23 }	48.65
Mean	53.46	40.49	36.05	46.74	31.27	

S.E. (Sprays) = 2.96

S.E. (Prunings) = 3.82

TABLE II.
FRUIT DROP (PER CENT.)—SOUTHERN HALF OF PLOT.

Spray Treatment.	Pruning Treatment.					Mean.
	1	2	3	4	5	
.0005%	49.05 50.40	52.79 59.73	52.29 67.09	45.36 44.68	45.18 } 55.04 }	52.16
.001%	60.32 51.99	50.82 51.45	47.69 53.57	39.13 42.37	59.25 } 44.70 }	50.13
Control	73.72 71.43	42.67 52.73	69.23 57.47	17.29 47.23	27.84 } 49.18 }	50.77
Mean	59.49	51.70	57.89	39.33	46.87	

S.E. (Sprays) = 4.77

S.E. (Prunings) = 8.72

TABLE III.
NORTHERN HALF OF PLOT.

Variation.	D.F.				Sum of Squares.	Mean Square.	Variance Ratio.
Blocks	1				377	377.0	4.29*
Prunings	4				1835	458.4	5.22*
Sprays	2				1116	558.0	6.35**
Interaction	8				284	35.5	0.40
Error	14				1230	87.9	
Total	29				4842		

* Significant at 5%.

** Significant at 1%.

Northern Half of Plot. It is clear from Table I that the application of the spray at 10 parts per million caused a reduction of 15% in the fruit drop. The reduction caused by the lower concentration is not significant. In view of the fact that a whole month had elapsed between the application of the spray and the picking date, this result can be regarded as satisfactory.

Of the pruning treatments, treatment 1 (the unpruned plots) gave the heaviest drop, being significantly greater than that from the two open centre treatments, 2 and 3, and from the modified leader summer pruned treatment, 5. Summer pruning evidently reduced the drop from the modified leader trees

(treatments 4 and 5) and in the case of the open centres too, although in the latter case the difference is not significant.

It will be seen from Table III that the interaction between spray treatment and pruning treatment is not significant, so that the difference in the amount of fruit dropped from trees receiving different pruning treatments is independent of the spray treatment. This means that the result is not connected with the ease with which the fruit can be wetted under different systems of pruning but is probably related to the wind resistance offered by the branches or the position of the fruits on the tree. The unpruned trees presented a bigger surface to the wind and were shaken more severely, and for a similar reason the summer pruned trees were less affected.

Southern Half of Plot. As regards the southern half of the plot, Table II shows that the spray treatment produced no significant differences. This part of the plot is more exposed to the wind and evidently the force of the gale was sufficient to swamp any differences there might have existed. The unpruned trees again showed most fruit drop, but the other differences are not sufficient to warrant discussion. It was unfortunate that the gale occurred just when the effect of the first spray was wearing off and before the second application had had time to take effect, and also that the first sign of wind since the spray was applied should have been a 50 m.p.h. gale. A less severe test of the treatments would no doubt have brought out the effect of the spray on both halves of the plot more satisfactorily.

A word of warning is perhaps necessary in regard to a possible effect of growth substances on the human organism. There is no evidence to show that growth substances might cause cell proliferation in animals as they do in plants, and Gardner says the possibility is remote with the quantities likely to be left on the fruit. Vyvyan (2), however, has initiated experiments to settle the point definitely before recommending the use of the substances on apples, and no doubt it would be advisable to postpone commercial application of these methods until tests have shown the substances to be harmless.

Summary.

Trees of the variety King Edward VII growing under five different pruning systems were sprayed with alpha-naphthalene acetic acid solution at two concentrations to reduce pre-harvest drop of fruit. Spraying with a .001% solution reduced fruit drop appreciably when the trees were subject to a 50 m.p.h. gale. Drop from pruned trees was less than from unpruned trees and summer pruning reduced the drop compared with trees only winter-pruned.

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NOTE ON THE USE OF OIL EMULSIONS TO PROLONG THE STORAGE LIFE OF APPLES.

By W. E. BERRY.

The storage life of apples can be lengthened by several methods designed to reduce the rate of ripening. Gas and cold storage are well-known means of attaining this end. More recently the restriction of gas exchange through the skin by applying a thin film of wax or oil has been found effective.

Experiments at the Ditton Laboratory have demonstrated that the storage life of Bramley's Seedling and Newton Wonder apples dipped in an emulsion of olive or arachis oil, can be prolonged from four to six weeks compared with untreated controls. A concentration of 12% oil was found to be most effective. Other vegetable and mineral oils were tried with varying results. A preparation known as Ditton Apple Dip has been recommended for use with the above mentioned varieties, consisting of a stock emulsion containing 60% arachis oil with 5% sodium oleate, to be diluted to 12% oil before use.

None of the treatments tried is recommended for use with dessert varieties as the flavour is thereby spoilt.

Treatments.

It was decided here to try, on a small scale, the effect of several oil emulsions on varieties not reported on by Ditton.

The following stock emulsions were made up, with the exception of the Ditton Dip, which was kindly supplied by Mr. C. R. Furlong, of the Ditton Laboratory.

1. 60% arachis oil and 5% sodium oleate (Ditton Dip).
2. 67% raw linseed oil + 33% of 10% sulphite lye.
3. 67% raw linseed oil + 33% of 5% sodium oleate.
4. 67% medicinal liquid paraffin + 33% of 10% sulphite lye.
5. 67% medicinal liquid paraffin + 33% of 5% sodium oleate.

All the emulsions were used after dilution with rainwater to 10% of the stock. The final emulsions thus contained 6.7% of oil with the exception of the arachis oil which contained 6%. The apples used were the culinary varieties King Edward VII and Crawley Beauty, and Cox's Orange Pippin.

The diluted emulsions were placed in suitable vessels and the apples immersed for a few seconds, drained and spread on paper to dry. The linseed oil and liquid paraffin emulsions left the apples much greasier on the surface than did the arachis oil.

When the surface of the fruits was dry, the apples were spread on trays and placed in a common fruit store, together with untreated controls.

At the time of treatment, October 21st, the Edwards had just been picked and were an excellent sample of the variety, perfectly green and firm. The Crawleys and Cox's had been picked for some time. The former were still green, but the Cox's were a poor sample and already turning yellow.

Results.

The fruits were examined at intervals until February 10th, when it was

decided to terminate the experiment. On this date the condition of the apples was as follows :—

The untreated controls of Edward were completely yellow. The flesh was still quite firm, but occasional fruits showed a slight amount of pit. The untreated Crawley Beauties were all yellow and slightly shrivelled, but otherwise appeared sound. The Cox's were quite yellow and flaccid.

None of the treatments proved to be successful with the Cox's Orange Pippins, for whilst some kept their colour longer than the controls and water loss was reduced, all developed an unpleasant fermented taste which quite spoilt the natural flavour.

The Crawleys treated with arachis oil and linseed oil were all yellow and slightly shrivelled and the linseed oil had produced bad lenticel spotting with Treatment 2 and slight spotting with Treatment 3. Both the liquid paraffin treatments appeared to have delayed the maturing of the Crawleys more than the other treatments and there was no spotting or shrivelling.

The Edwards treated with arachis oil were partly yellowed and there was a slight degree of lenticel spotting. The general condition was good and the flesh crisp. Those treated with linseed oil and sulphite lye were green and the flesh firm and crisp, but there was a high degree of lenticel spotting which was already obvious by early December. Apparently the oil had penetrated the lenticels, and had discoloured the flesh an appreciable distance beneath the skin. Fig. 1 illustrates the degree of spotting produced. The Edwards treated with linseed oil and sodium oleate were turning yellow and most were badly spotted, the spots having turned to rots on some fruits.

Treatment 4, liquid paraffin with sulphite lye, gave the best results with the Edwards. The apples were dark green and in perfect condition. There was no spotting and the flesh was hard and crisp. They appeared not to have changed since they were put into store and seemed capable of keeping for a considerable time longer. Treatment 5, liquid paraffin with sodium oleate, produced very similar results but the fruits were not quite so green.

Effect on taste after cooking.

Samples of the Edwards and Crawleys were stewed in the usual way, and baked in their skins. The linseed oil treatments imparted a distinctly unpleasant taste to both varieties when cooked with or without the skins. The other treatments had no noticeable effect on taste. The Edwards cooked very well and remained quite white. The Crawleys on the other hand were all discoloured and were probably over-mature.

Conclusions.

These preliminary tests indicate that liquid paraffin emulsions can be used very successfully to prolong the storage life of the variety Edward VII, and that arachis oil (bearing in mind that it was used here at a lower concentration than that recommended in Ditton Dip) was not so good. Linseed oil proved useless with the varieties tested. The results with Cox's Orange Pippin confirm those at Ditton with regard to the effect on flavour. The results with Crawley Beauty were fairly satisfactory but would no doubt have been better if the fruit had been treated sooner after picking.

The present price of pure liquid paraffin is 14/- per gallon, and arachis oil about 8/-. Since a ton of apples uses up about 1 gallon of emulsion, 1 gallon of oil should suffice for about 15 tons of apples at the concentrations used.



FIG. 1. King Edward VII. Left, Control. Middle, Liquid Paraffin and Sulphite Lye.
Right, Linseed Oil and Sulphite Lye.

MANURIAL EXPERIMENTS ON VEGETABLE CROPS.

I. EFFECTS OF FARMYARD MANURE AND OF VARIOUS FERTILISER TREATMENTS ON SAVOYS AND CARROTS.

By T. WALLACE, H. E. CROXALL, and P. T. H. PICKFORD.

The results reported in this paper are for the first two crops grown in a rotational experiment on vegetables commenced in June, 1940.

It is proposed to continue the experiment over a period of several years and to issue reports from time to time at appropriate stages.

Prior to using the plots for the vegetable experiment they had been used for a similar experiment on strawberries which had run continuously since 1924. As will be seen below the manurial treatments were slightly modified on the change over from strawberries to vegetables but essential points of the strawberry treatments, such as farmyard manure, complete fertiliser and deficiencies of nitrogen, phosphate and potash, were retained, rates of dressings only being changed.

In this way the results for vegetables are in part due to the cumulative effects of treatments dating from 1924.

Six new plots were added to the original plots when the vegetable experiment was begun. The object of these plots was to compare the effects of muriate of potash and common salt. During the strawberry period they had all received a complete fertiliser treatment identical with that given to the "complete fertiliser" strawberry plots.

The results reported for savoys and carrots are of special interest in that they refer to two crops with widely differing manurial requirements.

Plot Layout and Manurial Treatments.

The plots are laid out on the randomized block system, each treatment being in triplicate. The muriate of potash and salt plots are located at one end of the experimental area and under the new arrangement the experimental plots are contained in a rectangle with six plots along the length and four plots across the width. The plots each measure 34 ft. $\times$ 22 ft. 6 in. (approx. 1/60 acre) and are separated from one another by alleyways measuring 3 ft. 6 in. along the plots and 6 ft. across the plots. In the vegetable experiments these alleyways are planted in the same way as the experimental plots and are given a complete N, P, K fertiliser. They thus serve as buffer strips between the treated plots.

The original scheme of manurial treatments for the strawberries was as follows:—

Treatment J. Control: No manure.

Treatment K. Complete fertiliser (N, P, K) comprised of sulphate of ammonia, superphosphate and sulphate of potash to give 40 lb. N, 48 lb. P_2O_5 , 50 lb. K_2O , applied annually in spring.

Treatment L. Omit nitrogen: P, K as in *K*.

Treatment M. Omit phosphate: N, K as in *K*.

Treatment N. Omit potash: N, P as in *K*.

Treatment O. Farmyard manure at 20 tons per acre every third year prior to planting.

From 1927 the rates of N, P, K in the fertiliser dressings were altered as follows:—

Nitrogen: Nitrate of soda at 4 cwt. per acre—60 lb. N per acre.

Phosphate: Superphosphate at 3 cwt. per acre—48 lb. P_2O_5 per acre.

Potash: Sulphate of potash at 3 cwt. per acre—144 lb. K_2O per acre.

These latter rates were continued until the change over to vegetables in June, 1940.

The manurial scheme for vegetables provides for differing rates of nitrogen for different crops, according to their needs, ranging from 8 cwt. nitro chalk per acre for cauliflower and spring cabbage to 3 cwt. per acre of this fertiliser for carrots. Nitro chalk is proposed for all crops excepting potatoes on which sulphate of ammonia will be used. The rates of phosphate and potash will be kept at constant levels for all crops, the former at 4 cwt. per acre superphosphate (16% P_2O_5) and the latter at 2 cwt. per acre sulphate of potash. Muriate of potash and salt are each applied at 2 cwt. per acre.

For the first vegetable crops of the series farmyard manure was to be applied at a rate of 5 tons per acre to each crop and the previous control plot became a "nitrogen only" plot.

The management proposed for each crop was to be in accordance with good commercial practice in which hand work would be kept at a minimum.

Records.

In addition to quantitative data of crop yields, vigour records are taken at various stages during the growth of the crops and the observations are generally expressed as quantitative markings, which must be regarded only as approximations although representing visual differences. It is also proposed to supplement the field data by chemical investigations on growing crops and harvested produce, and on the soils of the plots.

In certain cases storage tests on the crops will also be carried out.

EXPERIMENT ON SAVOY CABBAGE.

Savoys comprised the first crop to be grown in the series. The variety was Ormskirk Late Green and planting was carried out during the latter part of June, 1940.

In this experiment nitro chalk at 6 cwt. per acre was used as the nitrogenous dressing, and phosphates, potash and salt were at the standard rates for the experiment. The rate for farmyard manure was 5 tons per acre.

The manure and fertiliser dressings were applied before planting (the salt two weeks previous to planting), the former being ploughed in and the latter broadcast and harrowed in.

Observations on Growth.

The weather during the early stages greatly retarded growth.

June was a very dry month and the soil became very dry, which resulted

in the plants being severely checked both in the seed bed and after planting out. The whole of July was very wet and sunless and the checked plants made little progress. August and September were again very dry and during the latter month the soil was again abnormally dry and all crops showed signs of water shortage. It was thus not until October that the plants began to grow vigorously.

The plots were marked for vigour on seven occasions between September 11th and January 17th and it was considered that the cutting stage had been reached during early January. Harvesting, however, was not carried out until February 12th since this had to fit into the marketing scheme for the season. The effect of this late marketing was undoubtedly to diminish the differences between the best and poorest plots, since on the best plots, especially treatment N, the plants were ready for cutting somewhat ahead of the others. The order of vigour for the various treatments at each marking was the same, in order of descending vigour N, K, J, M, O, L, with the exception that on three occasions the positions of treatments M, O, were reversed. At all times vigour under these two treatments was very similar. The extra plots, receiving muriate of potash and salt respectively, showed vigour comparable with N on all occasions and may be considered as giving excellent results.

Throughout the experiment the most outstanding point was the nitrogen starved appearance of the plants under treatments L. (omit nitrogen) and O. (dung), and nitrogen supply was obviously the predominant factor in producing healthy growth, green colour and vigorous development. Coloured photographs were taken on November 14th to show the yellowing effect from low nitrogen and the quantitative data for yields show that where nitrogen was low a very considerable proportion of the plants never "hearted" and remained as "greens."

The outstanding plots for vigour throughout were plots N. (omit potash) and it should be noted that potash has not been applied to these plots since 1924.

On plots M. (omit phosphate) the plants were particularly poor and showed much blue and purple tinting from planting until October.

Some idea of the relative vigour at various stages is given by the following marking records. (12 points regarded as maximum).

September 11th :

N.	Muriate.	Salt.	K.	J.	O.	M.	L.
10½	9¼	9	8¾	7¾	7½	6	4½

December 5th :

Muriate.	Salt.	N.	K.	J.	M.	O.	L.
10½	10½	10¼	9¼	7¼	7¼	7	3½

January 17th :

N.	Salt.	Muriate.	K.	J.	M.	O.	L.
10½	10¼	10	9¼	7½	7	6¼	3

Yields.

Data were obtained for total yields, and these were divided into marketable heads and greens.

The total yields were analysed by the method of variance, excepting

the muriate and salt plots which do not fall into the original randomized block layout. Before making the analysis it was necessary to adjust the data slightly to avoid doubtful boundary effects mainly due to the fact that the rows were not exactly parallel with the sides of the plots.

In the table of Total Yields below, mean yields per plot are given in lb. per plot and the corresponding tons per acre. Greens are shown as percentages of total yields. For savoys the yields are definitely low and this can be attributed to the very unfavourable weather conditions which occurred until October.

TABLE I.
YIELDS OF SAVOYS.

Treatment and Plot Letter.	Omit Potash (N).	Complete Fertiliser with KCl.	Complete Fertiliser (K).	Nitrogen and Phosphate with NaCl.	Nitrogen only. (J).	Omit Phosphate (M).	Farmyard Manure. (O).	Omit Nitrogen. (L).
Mean Yields per Plot (lb.) ..	275	275	265	265	228	220	202	142
Yields per Acre (tons) ..	7.4	7.4	7.1	7.1	6.1	6.0	5.5	3.8
Greens as % Totals ..	12.7	19.6	16.8	16.3	24.4	39.3	34.4	67.4

Total Yields—Significant difference 5% point = 63.5 lb.; 1% point = 90.25

The statistical analysis shows that all plots from N to M in the above table have significantly higher yields than L to at least the 5% point, and N and K to the 1% point. N and K are also significantly higher than O to the 5% point whilst O is almost significantly greater than L.

In addition to the differences in total yields it will be noted that there is a wide range in the values for greens as % of total yields, varying from 12.7% greens for (N) to 67% greens for (L). It should be noted that the high percentages of greens were associated with low nitrogen and low phosphate conditions—treatments (L) and (O) low N, and treatment (M) low phosphate.

The results thus demonstrate the predominant importance of nitrogen and the ineffectiveness of potash; dung is shown to be too low in nitrogen at the low rate used; and chlorides if not effective in raising yields have not produced any harmful effects.

EXPERIMENT ON CARROTS.

The savoys were followed by carrots, the variety used being Blatchford's Stump Rooted. A sowing, using 3 lb. seed per acre, was made on April 22nd, 1941, but, owing to very dry weather conditions which followed, germination was very patchy and a second sowing at the same rate was made on May 19th and this was highly successful, a very even plant being obtained over the whole of the plots.

The nitrogenous dressing used consisted of nitro chalk at 3 cwt. per acre and farmyard manure was again applied at 5 tons per acre. The salt and muriate of potash dressings were applied a fortnight before the first sowing. The manure was ploughed in and the fertilisers broadcast prior to the first sowing.

A first weeding between the rows was made with a push-hoe as soon as

the carrot rows were clearly visible and this was followed by hand-weeding of the rows at the end of June. Unfortunately, due to weather and pressure of other work, it was impossible to carry out the weeding of the whole of the plots within the space of a day or so and as a result weed growth seriously checked growth on six of the plots—K3, L3, N1, salt 1 and 5, muriate 6—and as the effects of this check was evident throughout the experiment it was decided to discard these plots in considering yields.

No thinning was done and after the hand weeding, the tops made such rapid growth that further weeding was unnecessary.

Observations on Growth.

Germination was excellent and plants were very evenly spaced on all plots, the numbers of plants perhaps being slightly higher under "omit nitrogen" and farmyard manure treatments.

Growth from the outset was very vigorous and the crops on all plots were doubtless abnormally large due to seasonal influences. Vigour markings on the tops were made on three occasions, the points assigned (12 maximum) being as follows:—

July 15th:

Salt.	Muriate.	O.	L.	M.	J.	N.	K.
10 $\frac{1}{4}$	10 $\frac{1}{4}$	10	8 $\frac{3}{4}$	8 $\frac{1}{2}$	8 $\frac{1}{4}$	8	

August 5th:

Salt.	O.	Muriate.	J.	N.	M.	K.	L.
11 $\frac{1}{2}$		11	10	9 $\frac{3}{4}$	9 $\frac{1}{4}$	8 $\frac{3}{4}$	

September 12th:

Salt.	Muriate.	M.	N.	O.	J.	K.	L.
11 $\frac{3}{4}$	11 $\frac{1}{4}$	11	9 $\frac{3}{4}$	9 $\frac{1}{2}$	9 $\frac{1}{4}$	9	5 $\frac{3}{4}$

It will be noted that the salt and muriate treatments produced the most vigorous top growth. In the earliest stages, the dung (O) and omit nitrogen (L) plants were relatively vigorous but the latter fell greatly behind as growth proceeded. At the last marking omit phosphate (M) stood out markedly for vigour and colour.

From an early stage "omit nitrogen" and farmyard manure plots showed up distinctly by their pale foliage and no specific symptoms were shown for other treatments. On October 22nd observations were made on tinting and ripening of the foliage. The outstanding points in this connection were the fresh green colour on "omit phosphate" (M) plots, and the extreme yellowing and paleness on "omit nitrogen" (L) plots. Farmyard manure plots also showed out clearly for pale colour of foliage whilst on the muriate and salt plots there was a tendency for red tints to develop.

Observations made on the roots showed that these were abnormally large and appeared to exhibit much splitting on all plots by early September.

Yields.

The following data were obtained for each plot on unwashed but hand cleaned roots: weights of sound roots; weights of split roots; and by the summation of these values, total weights.

A statistical analysis was carried out on the data, other than for the salt and muriate of potash plots, for total weights, weights of sound roots and percentages of sound roots.

As the effects of the checks resulting from the failure to deal with the weeds in the hand weeding stage were clearly evident in the greatly reduced yields from the affected plots, these plots were treated as missing plots in the statistical analysis, in accordance with the method of Yates.

TABLE II.
TOTAL YIELDS OF CARROTS.

Treatment and Plot Letter.	Nitrogen and Phosphate with NaCl	Omit Phosphate (M)	Farmyard Manure (O)	Complete Fertiliser (K)	Complete Fertiliser with KCl	Omit Nitrogen (L)	Nitrogen Only (J)	Omit Potash (N)
Mean Yields per Plot (lb.) ..	1433	1330	1290	1289	1285	1216	1202	1152
Yields per Acre (tons) ..	38.4	35.6	34.6	34.6	34.4	32.6	32.2	30.9

Significant difference 5% point = 92 lb.; 1% point = 136 lb.

TABLE III.
YIELDS OF SOUND CARROTS.

Treatment and Plot Letter.	Farmyard Manure (O)	Omit Nitrogen (L)	Nitrogen Only (J)	Omit Phosphate (M)	Complete Fertiliser (K)	Omit Potash (N)	Nitrogen and Phosphate with NaCl	Complete Fertiliser with KCl
Mean Yields* per plot (lb.) ..	1059	1047	932	896	851	820	804	797
Yields per Acre (tons) ..	28.2	28.0	25.0	24.0	22.8	22.0	21.4	21.3
Sound Carrots as % of Total Yields	82.0	86.2	77.5	67.4	66.0	71.2	55.0	59.9

* Significant difference 5% point = 240 lb.

The main points which emerge from the quantitative data are as follows :

Total yields : The yields obtained from all treatments were extraordinarily high, which must be attributed to seasonal influences since yields throughout the district were well above normal. Omit phosphate treatment produced the highest yields and here it should be noted that the plots had not received any phosphatic manures since 1924, so that it would seem that phosphatic requirements under field conditions are very low. The yield for this treatment was significantly higher than for "omit nitrogen," "nitrogen only" and "omit potash." Farmyard manure and complete fertiliser treatments gave identical yields which were significantly higher than for "omit potash." Salt treatment gave the highest yields and the yields on the muriate of potash plots were similar to those for the complete fertiliser plots (K).

It would seem from these results that potash omission was the most important factor in reducing yield, this result being completely opposite from that obtained for the savoys. Phosphates appeared unnecessary and phosphatic manuring may tend to reduce yields on these plots (cf. M > K and J > N). The omission of nitrogen although very clearly evident in reducing top growth did not exert a large influence on root growth (cf. K and L) and it may be concluded that the requirements of carrots for nitrogen are relatively low. This is also shown by the high yields on the farmyard manure plots.

Salt was probably very effective in raising yields, more so than muriate of potash, and muriate of potash seemed to be similar to sulphate in effect.

The yields of sound carrots reflect the amount of splitting which occurred, which was very large, ranging from 14% to 45% of the total crops, according to treatments. The variation in splitting within treatments was very large and for this reason differences, excluding the NaCl and KCl plots which are not included in the analysis, are not significant.

However, it should be noted that the two low nitrogen treatments (O and L) head the list of yields for sound roots, whilst the high yielding chloride plots are at the bottom. Hence it is suggested that splitting is accentuated by high nitrogen and chloride treatments.

Summary.

1. A scheme for a fertiliser experiment on vegetable crops grown in rotation is described. The object is to examine the effects of continuous manurial treatments, with special reference to the effects of farmyard manure, deficiencies of N, P and K and the use of chlorides, including common salt, on a variety of vegetable crops.

2. The plots were used for a similar experiment on strawberries from 1924-1940 and the farmyard manure and deficiency treatments date back to the beginning of this experiment. Salt and muriate of potash treatments were commenced in 1940 at the beginning of the vegetable experiment.

3. Results are reported for the first two vegetable crops—savoy and carrots.

4. For the savoy crop nitrogen was of outstanding importance ; phosphate omission also appeared to be deleterious ; potash omission, in contrast to nitrogen omission, was associated with the highest yields.

Farmyard manure was too low in nitrogen content for this crop. Salt and muriate of potash gave good yields and did not produce any harmful effects.

5. The yields of carrots were abnormally high, probably due to seasonal influences.

In contrast to the savoy, potash supply was of great importance and nitrogen omission of much less importance. Potash omission resulted in the lowest yields. Phosphate omission gave the highest yields and the requirements for phosphate would thus appear to be low for carrots on these plots. The nitrogen requirements of carrots in the field are probably low, as judged by the results for "omit nitrogen" and farmyard manure treatments, in both of which cases the tops indicated very low nitrogen conditions but good yields of roots were obtained. Both salt and muriate produced high yields.

Splitting was very prevalent and appeared to be reduced in amount by low nitrogen conditions and to be increased by chlorides.

NOTE ON THE EFFECT OF MANURIAL TREATMENTS ON THE CAROTENE CONTENT OF CARROT ROOTS.

By A. POLLARD.

As carotene is, from the point of view of nutrition, one of the most important constituents of the carrot, the effect of manurial treatments upon the production of carotene by the root may be of some significance at the present time. Carotene determinations have accordingly been carried out on the material obtained from the manurial plots described above.

Samples of carrots (15 lb.) were taken at random from each of the three plots receiving each treatment and the samples corresponding to each treatment pooled. The carrots were washed, sliced and minced and, after thorough mixing, samples were taken for analysis. Different samples from any particular batch gave analyses varying by about 5% and average figures are given in the table below.

The differences in the carotene values for carrots receiving different treatments are not very great, but the values given by those receiving high nitrogen additions (N, M, J, K) are uniformly greater than those given by the plots receiving little or no nitrogen (O, L). The addition of chlorides in two cases (salt, muriate) gave intermediate values for carotene although the nitrogen supply was no less than in the first treatments.

The production of carotene by the root therefore seems to be dependent upon an adequate supply of nitrogen, as is found for the green leaf, and may be adversely affected by the presence of chloride.

TABLE IV.

Treatment and Plot Letter.	% Dry Weight.	Carotene : mg./100 gm. dry material.
(L) Omit nitrogen	11.0	100
(O) Farmyard manure	10.6	109
(N) Omit potash	10.6	127
(M) Omit phosphate	10.3	130
(J) Nitrogen only	11.2	131
(K) Complete fertiliser	11.0	125
Nitrogen and phosphate with NaCl ..	10.5	115
Complete fertiliser with KCl	10.5	116

} Low N group

} High N group

} High N plus chloride

MANURIAL EXPERIMENTS ON VEGETABLE CROPS.

II. EFFECTS OF FARMYARD MANURE AND OTHER MANURIAL TREATMENTS ON SAVOYS AND EARLY POTATOES.

By T. WALLACE, H. E. CROXALL and P. T. H. PICKFORD.

The results reported in this paper are for the first two crops grown in a rotational experiment on vegetables, commenced in June, 1940, and to be run concurrently with that described in Part I of this series.

The areas utilised for the two experiments adjoin and both had been used continuously since 1924 for experiments on the manuring of strawberries. As in the case of the experiment in Part I, the manurial treatments proposed for the vegetables in the present experiment are mainly those given to the strawberries with modifications in rates of the dressings, though certain new treatments have been introduced to study special problems. Here again the results for the vegetables must be regarded in part as due to cumulative effects of treatments given to the strawberries. (See results reported later *re* magnesium deficiency.)

The results are again of particular interest in that they relate to two crops with widely differing manurial requirements.

Plot Layout and Manurial Treatments.

The plot layout and manurial treatments have been previously described in detail in reporting the results of the strawberry manurial experiment (1). The general scheme of layout is similar to that described in Part I. The area measures approximately 230 yds. by 100 yds. and contains 24 manurial plots, each 34 ft. $\times$ 22 ft. 6 ins. (approximately 1/60 acre) and separated from each other by wide alleyways, which in the vegetable experiments are cropped with the same vegetables as the plots and are manured with a complete N, P, K fertiliser, thus acting as buffers between the manurial plots.

The original manurial treatments given to the strawberries were as follows, each treatment being in triplicate:—

Treatment A. Farmyard manure at 20 tons per acre, every third year.

Treatment B. Farmyard manure at 10 tons per acre every third year plus a complete inorganic fertiliser—sulphate of ammonia (20 lb. N*), superphosphate (75 lb. P_2O_5), sulphate of potash (50 lb. K_2O).

Treatment C. Shoddy—basis 5% N—at 2 tons per acre every third year, plus steamed bone flour (75 lb. P_2O_5), sulphate of potash (50 lb. K_2O).

Treatment D. Complete “organic” non-bulky manure containing dried blood (40 lb. N), steamed bone flour (75 lb. P_2O_5), sulphate of potash (50 lb. K_2O).

* Values in brackets rates per acre, applied annually in spring.

Treatment E. Complete inorganic fertiliser containing sulphate of ammonia (40 lb. N), superphosphate (75 lb. P_2O_5), sulphate of potash (50 lb. K_2O).

Treatment F. As D, but omitting potash.

Treatment G. Farmyard manure in two applications, 12 and 8 tons per acre respectively (total 20 tons per acre) each three year period.

Treatment H. No manure.

The above treatments were given from 1924-1935, when the following alterations were made for the period 1936-1940 inclusive.

1. Annual dressings of N, P_2O_5 , and K_2O were at rates of 45 lb. N; 48 lb. P_2O_5 ; 96 lb. K_2O .
2. Nitro chalk was used *vice* sulphate of ammonia.
3. In Treatment B rates of N, P_2O_5 and K_2O in artificials were all at half rates of E.

Manurial treatments in the vegetable scheme are as follows, the dressings being given to each crop grown and not on a *per annum* basis.

Treatment A. Farmyard manure (high rate) 10 tons per acre.

Treatment B. Farmyard manure (low rate) plus Inorganic Nitrogen. Farmyard manure at 5 tons per acre. Nitro chalk or sulphate of ammonia at half rates in E.

Treatment C. Vegetable Compost (low rate) plus Inorganic Nitrogen. Vegetable compost at 5 tons per acre. Nitro chalk or sulphate of ammonia at half rates in E.

Treatment D. Complete Fertiliser (Organic N). Hoof—at rate of 2 N in E. Superphosphate and sulphate of potash as for E.

Treatment E. Complete Inorganic Fertiliser (using Sulphate of Potash). Nitro chalk or sulphate of ammonia at various rates according to crops. Superphosphate (16% P_2O_5) at 4 cwts. per acre. Sulphate of potash (48% K_2O) at 2 cwts. per acre.

Treatment F. Complete Inorganic Fertiliser (using Potash Salts). As E, but using 30% potash salts for K_2O .

Treatment G. Town Refuse Materials (high rate). Rate of N to be twice rate in E.

Treatment H. Complete Inorganic Fertiliser plus Magnesium Sulphate. N, P, K as in E. Magnesium sulphate (calcined Kieserite, 30% MgO) at 1 cwt. per acre.

Notes.

1. The high and low rates of farmyard manure, compost and town refuse materials are subject to alteration in the light of experience.
2. Rates of nitrogen and forms of nitrogenous fertiliser will be altered to meet the differing needs of various brassicae, potatoes, root crops, etc.

3. Various materials which appear of interest from time to time will be used in Treatment G.

Management throughout the experiments will be in accordance with good commercial practice and hand work will be kept to a minimum.

Records.

Procedure in recording and the types of records obtained will be similar to those described in Part I.

EXPERIMENT ON SAVOY CABBAGES.

As in the case of the experiments recorded in Part I, the first crop to be grown was savoys, variety Ormskirk Late Green, which was also grown over the period late June, 1940—February, 1941, so that the savoy crops in the two experiments were grown concurrently.

As will be the usual practice in these experiments, the bulky manures were ploughed in and the fertilisers broadcast just prior to planting.

The nitrogen dressing in Treatment E was in the form of nitro chalk at 6 cwt. per acre, other nitrogenous dressings being adjusted accordingly.

For the Town Refuse treatment a well-known commercial product was used.

Observations on Growth.

The general progress of growth was similar to that recorded for the savoys in Part I, the plants remaining in a checked condition until October due to unfavourable weather conditions. The bad effects of the check were accentuated by sporadic aphid attacks which affected many plants severely throughout the growth period.

The plants were marked for vigour on seven occasions between September 11th and January 17th. The crop reached the cutting stage in early January but was not cut until February 12th. The latter fact tended to reduce differences between the more forward and backward plots.

The most outstanding points in the observations were : the poor, nitrogen-starved appearance throughout of the plants under Treatment G (town refuse) ; the relatively poor, low nitrogen appearance in Treatments A and B (both farmyard manure treatments) ; the high standard of vigour in Treatments C and F (vegetable compost, etc., and complete artificials with potash salts respectively).

In the early stages the plants under Treatment D (hoof, etc.) were relatively poor, but they improved rapidly after November.

The relative vigours at three stages during the growth period are indicated by the following table of vigour markings, in which 12 is the maximum number of points possible.

September 11th.

Order :	F.	C.	H.	A.	E.	B.	D.	G.
	10 $\frac{3}{4}$	10 $\frac{1}{2}$	9 $\frac{3}{4}$		9 $\frac{1}{2}$		8 $\frac{1}{2}$	7 $\frac{1}{2}$

December 5th.

Order :	C.	F.	H.	D.	B.	E.	A.	G.
	10	9 $\frac{3}{4}$	9 $\frac{1}{4}$	9		8 $\frac{3}{4}$	8 $\frac{1}{4}$	7 $\frac{1}{4}$

January 17th.

Order : C. F. H. D. B. E. A. G.
 9 $\frac{3}{4}$ 9 $\frac{1}{2}$ 9 $\frac{1}{4}$ 9 8 $\frac{1}{2}$ 8 6 $\frac{1}{4}$

Yields.

Records were obtained for total yields, which were subdivided into marketable heads and greens.

As in the concurrent experiment in Part I, the data for total yields were examined statistically, and in doing so slight adjustments were made in the plot yields to allow for differences in the numbers of rows per plot due to the plant rows not running parallel with the sides of the plots. Table I presents the data as mean yields in lb. per plot and as tons per acre, and also shows the greens as percentages of total yields.

TABLE I.
YIELDS OF SAVOYS.

Treatment and Plot Letter.	Vegetable Compost + N C.	Complete Inorganic with Potash Salts. F.	Complete Fertiliser with organic N. D.	Complete Inorganic with Sulphate of Potash E.	As E. plus Magnesium Sulphate. H.	Farmyard Manure 10 tons. A.	Farmyard Manure 5 tons. + N. B.	Town Refuse. G.
Mean Yield per Plot (lb.) ..	264	261	249	239	239	234	227	194
Yield per Acre (tons) ..	7.1	7.0	6.7	6.4	6.4	6.3	6.1	5.2
Greens as % Totals ..	17.1	13.3	21.7	20.2	19.8	23.3	28.0	37.0

Significant difference for 5% point = 42.5 lb.

The statistical analysis shows that the five Treatments C, F, D, E, H, all gave significantly higher yields than Treatment G, and it is clear both from the total yields and from the percentage greens that Treatments G, B, A, all noted as showing low nitrogen conditions during the experiment, tended to produce poor results.

The data thus indicate that the Town Refuse and Farmyard Manure treatments did not provide sufficiently high nitrogen conditions for healthy growth of the crop and thus support the conclusion in the parallel experiment that nitrogen is the dominant need of the savoy crop. It will be noted that the yields per acre from all plots were low and similar to those obtained in the Part I experiment, the low yields in both cases being attributed to the unfavourable weather conditions during the first three months of the experiment.

EXPERIMENT ON POTATOES.

The savoy crop was followed in 1941 by early potatoes, variety Sharpe's Express, using sprouted Scotch seed. Planting was carried out on all plots on April 17th.

The manures and fertilisers were as for the savoys excepting that sulphate of ammonia at 4 cwts. per acre was used as the standard dressing for the inorganic, nitrogenous fertiliser, and the necessary adjustments in rates of hoof and town refuse made in accordance with this fact.

Observations on Growth.

The plants grew away well from the beginning and by June clear differences

were evident in the haulms under the various treatments. The most vigorous growth throughout was associated with Treatments F and D, and the poorest growth with Treatments A and G, especially the latter. The haulm on F was slightly pale green, on D very dark green, on A somewhat pale, and on G exceptionally pale. The paleness in the latter two cases was typical of low nitrogen conditions, such as had been noted in the savoy experiment, thus confirming that these two treatments result in a low nitrogen status which leads to restricted vegetative growth.

By July 15th the growth of the haulm on all plots, excepting on Treatments A and G, formed a solid green cover.

Vigour markings were made on two occasions with the following results:—

June 28th.

Order :	F.	D.	E.	H.	B.	C.	A.	G.
	11½	10¾	10½		9¾		8	7½

August 5th.

Order :	F.	D.	H.	E.	C.	B.	A.	G.
	12		11½	11	10½	10	9	7½

During the course of the second marking symptoms of magnesium deficiency were noted on several of the plots and an estimate of the severity of these by categories in relation to the various treatments was made. The result of this survey was as follows:—

Magnesium deficiency symptoms :

Treatments H, F = Nil ; A, B, G = trace to very slight ; D = slight ; C, E = medium.

Samples of haulm were taken at random for ash analysis over two plots in each of the Treatments D, E, F, H, and the results obtained on these confirm the observations. (See note appended.)

Yields.

The crop was harvested whilst the haulm was still in a green condition, on August 15th.

The tubers were separated into two categories, large and small, by passing over a 1½" mesh riddle. In Table II data are given for each treatment as follows: mean total yield per plot (lb.) and as tons per acre; smalls as percentages of total yields. The data for total yields were analysed statistically.

TABLE II.
YIELDS OF POTATOES.

Treatment and Plot Letter.	Complete Inorganic with Potash Salts.	Complete Fertiliser with Organic N.	As E. + Magnesium Sulphate	Complete Inorganic with Sulphate of Potash.	Manure 10 tons.	Town Refuse.	Farmyard Manure 5 tons. + N.	Vegetable Compost + N.
	E.	D.	H.	E.	A.	G.	B.	C.
Total Yields (lb.) means per plot	467	425	421	415	395	376	371	359
Totals—tons per acre	12.5	11.4	11.3	11.1	10.6	10.1	9.9	9.6
Smalls as % total yields ..	22	24	26	25	28	24	27	31

Significant difference for 5% point = 56.6lb.

The statistical analysis shows that, at the 5% point of significance, Treatment F yields are significantly higher than those of A, G, B and C; D almost significantly higher than B and significantly higher than C; and H and E also higher than C. The treatments do not seem to have affected the proportions of smalls.

The order for total yields for the potatoes in the main is similar to that for the savoys, but there is one very notable exception in that Treatment C, which was top for savoys, is bottom for the potatoes. No reason can be suggested for this at present.

A further point of interest in the two experiments is the high yields with both crops from Treatment F, where potash salts are the source of potash in the complete fertiliser.

Summary.

1. A scheme for a fertiliser experiment on vegetable crops grown in rotation is outlined. The object is to examine the effects of various possible commercial dressings of manures and fertilisers on vegetables when applied to a number of consecutive crops with differing manurial requirements.

2. The plots were used for a manurial experiment on strawberries from 1924 to 1940 and some of the manurial treatments given to the strawberries are to be continued with slight modifications for the vegetables, so that cumulative effects from the past treatments may be studied.

3. Results are reported for the first two vegetable crops—savoys and early potatoes—grown in 1940 and 1941 respectively.

4. For the savoy crop the great importance of abundant nitrogen was again shown. Farmyard manure and a Town Refuse product gave poor results due to their inability to supply sufficient nitrogen. In the potato experiment the low nitrogen status of plants resulting from treatments with Farmyard Manure and Town Refuse was again evident, but the effects on yield were not so serious as in the case of the savoys.

5. Where potash salts were used as the source of potash in a complete fertiliser high yields were obtained with both crops. Magnesium deficiency symptoms developed in the foliage of the potato crop during the later stages of growth on all plots with the exception of those receiving magnesium sulphate and potash salts respectively. It cannot be stated at the present stage, however, that control was entirely due to these treatments owing to differences in the previous treatments given and particularly in respect of potash.

The incidence of magnesium deficiency in relation to four treatments was correlated with the magnesium contents of haulm samples from the respective treatments.

REFERENCE.

- (1) WALLACE, T. and VAIDYA, V. G. A Field Experiment on the Manuring of Strawberries *J. of Pomol. and Hort. Sci.*, 16, 148, 1938.

NOTE ON THE COMPOSITION OF POTATO HAULM FROM MANURIAL TREATMENTS D, E, F, H.*

By T. WALLACE, J. O. JONES and W. PLANT.

Samples of haulm were taken at random from two of the three replicates of each of the Treatments D, E, F, H, on August 5th, immediately after recording the incidence of magnesium deficiency on the plots. These four treatments were chosen for the following reasons: F and H both showed no symptoms and were undergoing different treatments each of interest to the magnesium problem—*i.e.* potash salts, containing chloride (1) and magnesium sulphate respectively; D showed only slight symptoms in comparison with E, which showed medium effects, and the nitrogen status of D was higher than in E, low nitrogen having been noted previously as associated with severe magnesium deficiency symptoms in fruit at Long Ashton.

The haulm in each case was separated into foliage and stems, and determinations were made of ash, CaO, MgO, K₂O and Cl.

In Table III the results are reported as averages of the two plots for each treatment, the individual values agreeing sufficiently closely to permit of this procedure.

TABLE III.

Treatment and Plot Letter.	Results as Percentages of Dry Matter.									
	Foliage.					Stems.				
	Ash	CaO	MgO	K ₂ O	Cl	Ash	CaO	MgO	K ₂ O	Cl
D. Hoof, Superphosphate, Sulphate of Potash	22.6	4.88	0.33	6.96	0.28	20.5	4.77	0.50	7.12	1.10
E. Sulphate of Ammonia, Superphosphate, Sulphate of Potash	19.0	4.47	0.16	6.54	0.34	21.7	5.32	0.34	6.87	1.35
F. Sulphate of Ammonia, Superphosphate, Potash Salts	19.7	6.43	0.66	4.19	1.93	17.6	5.28	1.01	5.16	4.54
H. As E. plus Magnesium Sulphate.	20.0	6.01	0.61	4.38	0.44	16.3	5.16	1.02	4.32	1.66

The points of interest are as follows :—

Magnesium. The values for MgO in both foliage and stems differ sharply between D, E (low) and F, H (high) and correlate well with the markings for magnesium deficiency on the plots, *viz.*: D = slight; E = medium; F, H = nil.

Potash. Prior to the vegetable experiments Plots D and E had received sulphate of potash annually from 1924-1940, whereas Plots F and H had not received any potash dressing. The results indicate that these treatments have greatly affected the potash status for the vegetables and that the present equal potash treatments accorded to the vegetables do not eliminate the differences due to the past dressings.

Because of these irregularities in potash status between the two groups it is impossible to determine the precise extents to which the potash salts and magnesium sulphate have been responsible for the control of the deficiency.

Chloride. It is clear that the potash salts have resulted in a large intake of the chloride ion into the plants and that this is revealed in both the foliage and stems.

REFERENCE.

- (1) GARNER, W. W., McMURTRY, J. E., BACON, C. W. and MOSS, E. G. Sand Drown, a Chlorosis of Tobacco. *J. Agr. Res.*, 23, 27, 1923.

* See previous article.

A NOTE ON THE EFFECTS OF FARMYARD MANURE AND OF VARIOUS FERTILISER TREATMENTS ON THE CONTENT OF ASH AND MINERAL CONSTITUENTS OF ASH IN THE CARROT CROP.

By T. WALLACE, J. O. JONES and W. PLANT.

In two previous papers in this Report (pp. 25-32) an account is given of a manurial experiment on carrots in which the effects of farmyard manure and various fertiliser treatments on yields and carotene contents of the roots are recorded and discussed.

In connection with the experiment it was considered of practical interest to determine the effects of the treatments on the contents of nitrogen and certain of the major ash constituents in the tops and roots of the plants. Although the nitrogen estimations are not yet complete, it has been considered desirable to present those to hand for the mineral constituents since such data for the crop under English conditions are lacking.

The data were obtained on samples of roots and tops taken at two stages, from 8—14th August, when the tops were well grown and the roots sufficiently large for marketing, and from 6th—8th November, when the roots were mature and the tops were beginning to die down.

The results show that certain ash constituents are affected by the different manurial treatments and are of practical interest in relation to potash, soda and chloride.

Experimental Procedure.

The method of sampling on the two occasions was similar. A number of plants—30 at the August sampling and 25 on the November date—were taken from each plot by digging single plants at approximately yard intervals from a number of rows picked at random. A small degree of selection entered into the sampling of the individual plants to ensure suitable specimens, in that only fairly well developed plants not touching neighbouring plants were taken. Apart from this the sampling was completely on a random basis. The plants were taken to the laboratory, where the roots were washed and dried with a cloth, and tops and roots weighed separately—roots only were weighed at second sampling owing to wet condition and ripening off of tops at this time. After weighing, representative samples of tops and roots, the latter after slicing, were dried on trays in a specially ventilated steam oven.

For the chemical estimations the dried samples were ground and portions for ash analysis were ashed in gold alloy dishes at a low temperature.

As the treatments in the field are all in triplicate all results reported below are means of three determinations.

Results and Discussion.

Fresh Weights.

The fresh weight data, on a basis of mean values per plant, are summarised in Table I.

TABLE I.
MEAN VALUES FOR ROOTS AND TOPS AND RATIOS RS/Ts.

Manurial Treatments.*	1st Sampling.			2nd Sampling.
	Mean Wt. 1 Root. gm.	Mean Wt. 1 Top. gm.	Root/Top.	Mean Wt. 1 Root. gm.
N. only	113	99	1.14	880
N.P.K ₂ SO ₄	122	105	1.16	896
P.K.	124	91	1.36	676
N.K.	134	112	1.20	828
N.P.	139	113	1.23	860
F.Y.M.	176	123	1.43	764
N.P.KCl	213	181	1.18	1100
N.P.NaCl	249	208	1.20	1076
Means—All Treatments	159	129	1.24	885

* For details of these see pp. 25, 28.

Whilst the sampling method was not adequate to provide accurate data on the relative sizes of the plants on the various plots, there are certain points which are brought out in the data, viz., the large size of the plants, both roots and tops, on the KCl and NaCl plots; the small size of the roots (second sampling) on the P.K. and F.Y.M. plots, both of which showed low nitrogen symptoms in the foliage, and the high ratios of roots to tops, R/T, on these plots.

It should be noted that at the second sampling the roots were from 4 to 8 times as large as for the first sampling on the various plots.

Dry Matter.

Data for dry matter as percentage fresh weight are available for roots for both samplings and for tops for the first sampling. Values for tops, second sampling, could not be obtained owing to the wet condition of the fresh material. The mean values obtained are shown in Table II.

TABLE II.
DRY MATTER AS PERCENTAGE FRESH WEIGHT—MEAN VALUES.

Treatment.	N. only.	N.P.K ₂ SO ₄ .	P.K.	N.K.	N.P.	F.Y.M.	N.P.KCl.	N.P.NaCl.
<i>1st Sampling.</i>								
Roots ..	10.8	10.5	10.1	9.8	9.6	10.1	9.0	8.6
Tops ..	14.4	14.9	15.5	14.5	13.6	14.2	12.5	12.6
<i>2nd Sampling.</i>								
Roots ..	10.9	9.9	11.5	10.5	10.0	10.6	8.8	9.9

The data suggest that low values for dry matter are associated with the two chloride treatments, a point which may be of importance in connection

with the large proportion of unsound roots (splits) harvested from these treatments. (See p. 30.)

Ash and Ash Constituents.

The results for roots and tops for the 1st and 2nd samplings are given in Tables III to VI. In the case of the values shown for ash and ash constituents in dry matter, significant differences have been calculated and are given at the bottom of the columns in the tables.

The plots receiving KCl and NaCl were not included in the statistical analysis as they are not contained in the randomised blocks formed by the other treatments. (See p. 25 for plot layout.) The results for these two treatments, however, may be compared with those of the main experiment in a general way and should provide pointers as to the effects of the chloride treatments.

The values for ash constituents as percentage ash are given primarily to show differences in ash composition between roots and tops and changes due to maturity in roots and tops respectively.

Roots. Although it is shown in Table I that the weights of roots had increased greatly between the two sampling dates—from a mean of 159 gm. to 885 gm. fresh weight per 1 root—both Table II and Tables III and IV show that as regards percentage dry matter, ash and ash constituents no marked changes had taken place.

Potash, which is the dominant constituent of the ash, affects the ash content, and thus the high values for ash in the main blocks are associated with potash manuring. It would seem also that the use of chloride fertilisers increases ash content. As regards ash constituents, the main significant differences due to manuring were for potash, soda and chloride. In the case of potash low values were obtained for the two treatments N only and N.P. in both samplings, and it should be noted that high potash values were obtained for both KCl and NaCl treatments, the latter presumably due to dressings of sulphate of potash given annually from 1924 to 1940 prior to the salt treatment.

The main points of interest in the soda values are the high values for the treatments N.P. and N only, where potash is not applied, and the lower values of this constituent on the plots where NaCl is given. It would appear from these results that soda can only accumulate freely in the roots when the potash status of the soil is low.

In the case of chloride content, both chloride treatments are marked by high values and farmyard manure treatment also shows high figures.

In the composition of the ash the points calling for comment are: the high percentage of potash and the fluctuation of potash content with potash manuring; the high percentage of soda where potash status is low—N and N.P. treatments—and the ineffectiveness of salt in raising the soda content where potash status is high in the soil; the high values for chloride where chlorides and farmyard manure are given.

Tops. The high content of ash in the dry matter of the tops is striking and there appears to be an increase in the values in passing from the first to the second sampling. This change is associated with changes in the proportions of certain constituents, notably CaO, K₂O and Cl, the content of CaO increasing and that of K₂O and Cl decreasing. The substantial decrease in K₂O is obviously due to the movement of large quantities of this constituent to the roots. Differences in ash content were only significant at the first sampling, but it is seen for both samplings that low values are associated with

the treatments of N and N.P. respectively, where potash is not given. Potash, soda and chloride contents are again significantly affected by manuring and similar features are shown as for the roots: high potash content where potash is applied and soil potash status is high—including NaCl plots; high soda contents where potash is not given—N and N.P.—and intermediate values for the NaCl treatment where soil potash status is high; high chloride values where chlorides are applied and a tendency to high values for farmyard manure treatment.

Since the carrot crop is afforded priority for imported potash supplies at the present time—1 cwt. of 60% muriate of potash per acre for the 1942 crop—it is of practical interest to calculate the amount of potash likely to be removed by an average crop—say 12 tons per acre—of main crop carrots. To do this we may assume 10% as the dry matter content of the roots and extreme values for potash in dry matter of 3% and 5% respectively. The smaller value gives 0.72 cwt. K_2O and the larger 1.2 cwt. K_2O per acre, equivalent to 1.2 cwt. and 2 cwt. per acre of muriate of potash (60% K_2O) respectively. If in addition an amount is added for potash remaining in the tops at harvesting it will be seen that the potash requirements of the crop are high. It is calculated from Tables I, II and V that, at the first sampling, between 0.26 and 0.44 cwt. K_2O , approximately, per acre would have been contained in the tops on the basis of a crop of 3 tons per acre of roots. This latter fact would point to the importance of not removing carrot tops from the field and to the drain of potash associated with the marketing of young carrots with tops attached.

Summary.

1. Determinations of ash and mineral constituents in ash have been made on the roots and tops of carrots at two stages of growth from manurial plots where farmyard manure and various fertiliser treatments were given.

2. It is shown that significant differences as regards the contents of ash, potash, soda and chloride in dry matter of roots and tops were produced by the treatments. Relationships between potash and soda contents are indicated.

3. The amount of potash required for an average crop of carrots, on the basis of the results, has been calculated.

TABLE III.
SHOWING ASH AS % DRY MATTER AND ASH CONSTITUENTS AS % OF ASH AND OF DRY MATTER.
ROOTS—1ST SAMPLING, 8—14/8/1941.

Treatment.	% Dry Matter.							% Ash.					
	Ash	CaO	MgO	K ₂ O	Na ₂ O	P ₂ O ₅	Cl	CaO	MgO	K ₂ O	Na ₂ O	P ₂ O ₅	Cl
N only ..	6.16	0.59	0.19	2.27	0.92	0.63	0.16	9.10	3.01	34.85	14.29	9.73	2.60
N.P.K. ..	8.73	.058	0.24	3.82	0.47	0.68	0.28	6.64	2.79	43.74	5.43	7.77	3.21
P.K. ..	8.56	0.57	0.18	4.11	0.33	0.55	0.25	6.66	2.04	45.42	3.92	6.36	2.92
N.K. ..	10.35	0.63	0.22	5.21	0.44	0.67	0.28	6.16	2.16	50.17	4.25	6.43	2.70
N.P. ..	8.42	0.62	0.23	3.11	1.27	0.67	0.24	7.41	2.80	36.03	15.14	7.84	2.85
F.Y.M. ..	7.87	0.53	0.17	3.91	0.31	0.64	0.37	6.97	2.15	49.14	4.21	8.17	4.70
N.P.KCl ..	9.75	0.63	0.21	5.18	0.39	0.87	0.47	6.49	2.13	51.47	4.01	8.97	4.81
N.P.NaCl ..	11.22	0.65	0.25	5.15	0.62	0.93	0.56	5.80	2.26	44.30	5.60	8.43	4.99
Significant Difference 5% Point	0.89	Not significant	Not significant	1.07	0.17	Not significant	0.05	—	—	—	—	—	—

TABLE IV.

SHOWING ASH AS % OF DRY MATTER AND ASH CONSTITUENTS AS % ASH AND OF DRY MATTER.
ROOTS—2ND SAMPLING, 6—8/11/41.

Treatment.	% Dry Matter.							% Ash.					
	Ash	CaO	MgO	K ₂ O	Na ₂ O	P ₂ O ₅	Cl	CaO	MgO	K ₂ O	Na ₂ O	P ₂ O ₅	Cl
N only	8.12	0.66	0.28	3.10	0.83	0.65	0.21	8.12	3.52	30.35	10.27	8.07	2.59
N.P.K.	9.92	0.62	0.23	4.62	0.41	0.64	0.29	6.29	2.31	46.70	4.20	6.55	2.92
P.K.	8.82	0.63	0.25	4.29	0.25	0.68	0.29	7.19	2.84	48.73	2.92	7.77	2.90
N.K.	9.49	0.62	0.22	4.19	0.56								
N.P.	8.53	0.61	0.21	3.18	1.23								
F.Y.M.	8.93	0.62	0.21	4.37	0.37								
N.P.KCl	11.13	0.69	0.23	5.53	0.44								
N.P.NaCl	11.70	0.73	0.28	5.19	0.67								
Significant Difference 5% Point	0.83	Not significant	0.03	0.39	0.21								

TABLE

SHOWING ASH AS % OF DRY MATTER AND ASH
TOPS—1ST SAMPLE

Treatment.	% Dry Matter.					
	Ash	CaO	MgO	K ₂ O	Na ₂ O	F
N only	14.90	3.51	0.16	4.53	0.67	0
N.P.K.	17.81	3.62	0.16	6.12	0.25	0
P.K.	19.02	3.76	0.17	6.61	0.16	0
N.K.	18.60	3.60	0.16	6.63	0.17	0
N.P.	16.61	3.96	0.18	3.80	0.74	0
F.Y.M.	18.89	3.75	0.17	6.77	0.27	0
N.P.KCl	18.81	3.45	0.53	6.57	0.23	0
N.P.NaCl	18.39	3.36	0.45	6.59	0.48	0
Significant Difference 5% Point	1.39	Not significant	Not significant	0.88	0.21	N significant

TABLE

SHOWING ASH AS % OF DRY MATTER AND ASH C
TOPS—2ND SAMPLE

Treatment.	% Dry Matter.												
	Ash	CaO	MgO	K ₂ O	Na ₂ O	P ₂ O ₅	Cl						
N. only	17.77	4.43	0.19	3.49	1.00	0.4							
N.P.K.	20.15	4.28	0.21	4.75	0.59	0.4							
P.K.	22.33	5.19	0.23	5.20	0.17	0.7							
N.K.	19.77	4.78	0.19	4.71	0.17	0.6							
N.P.	18.82	4.35	0.21	2.81	1.63	0.7							
F.Y.M.	20.15	4.58	0.23	5.04	0.24	0.88	1.00	22.67	3.39	25.03	1.22	4.39	4.96
N.P.KCl	19.79	4.17	0.68	5.09	0.54	0.83	1.35	21.05	3.44	25.67	2.74	4.19	6.82
N.P.NaCl	19.34	3.95	0.57	4.89	0.84	0.64	1.80	20.40	2.97	25.83	4.39	3.84	9.31
Significant Difference 5% Point	Not significant	Not significant	Not significant	0.71	0.54	0.18	0.11	—	—	—	—	—	—

MANGANESE DEFICIENCY OF AGRICULTURAL AND HORTICULTURAL CROPS.

SUMMARY OF INVESTIGATIONS, SEASON 1941.

By T. WALLACE and L. OGILVIE.

In the Annual Report for 1940 a note was included outlining the general problem of manganese deficiency in agricultural and horticultural crops and describing the occurrence of the trouble in the Bristol Province. In the latter connexion attention was drawn to the importance of considering manganese deficiency in relation to the ploughing-out of old grassland and the liming of certain classes of land. It was also shown how the deficiency had been induced in market gardens in Bristol by manurial practices.

During 1941 a close watch was again kept on the occurrence of the trouble on ploughed-out grassland and experiments were carried out on its control on Globe Beetroot grown in market gardens.

Occurrence on Ploughed-out Grassland.

The occurrence of the deficiency in relation to the ploughing-out of grassland showed little of fresh interest and in all cases recorded the soils could be placed into the categories listed in the previous paper.

The majority occurred on calcareous silt clays and the soils of the Puxton Series around Hewish, Somerset, were again noted to be highly susceptible when oats were taken as the first crop after grass. Other soils on which the trouble occurred were as follows :—

Thin alluvial wash over calcareous Keuper Marl—oats.

Haselor Series, calcareous grey clay with limestone, Rhaetic Beds—oats.

Calcareous silt clay, mainly Lower Lias material—wheat.

Calcareous silt clay, mainly Kimmeridge, over Chalk Gravel—wheat.

Colluvial Carboniferous Limestone—wheat.

Peaty sand over calcareous Carboniferous Limestone Valley Gravel—oats.

Badsey Series, calcareous sludge over calcareous Oolitic Gravel—oats.

Dark, humic sand from Upper Greensand, highly calcareous—apples, plums, potatoes.

The outstanding susceptibility of oats, among the cereals, was again confirmed, but it should be noted that wheat, though definitely much less susceptible than oats, may be severely affected on certain of the most difficult cases of the silt clays.

Control of Manganese Deficiency on Globe Beet.

The objects of the experiments were (a) to compare the efficiencies of manganese sulphate, manganese chloride and manganese ores when applied as fertilisers, and (b) to determine the minimum rates for manganese sulphate and manganese chloride when used as sprays. The trials at one centre also allowed of a comparison of the fertiliser and spray treatments.

(a) *Fertiliser Trial.*

The trial was carried out on a commercial crop of Globe Beetroot sown on

April 24th. The manganese materials used were manganese sulphate (32% Mn), manganese chloride (26% Mn), manganese ores (pyrolusite ores, containing 58% Mn). They were all applied at rates equivalent to 100 lb. per acre of manganese sulphate on April 29th. The trial was carried out as a randomised block experiment with the treatments, manganese sulphate, manganese chloride, manganese ores and no manganese, each in quadruplicate. The experimental area measured 80 yds. $\times$ 16 yds., and each of the sixteen plots for treatment was approximately 1/60th acre (10 yds. $\times$ 8 yds.).

As the crop was not harvested at an early stage, as is the usual custom, it was possible to carry out observations over a long period—until August 20th. Neither in this experiment nor in the spraying trials was it possible to obtain yield data.

The relevant observations were as follows :—

June 26th : Manganese sulphate and chloride similar and excellent control ; any effect of ores doubtful ; untreated plots, manganese deficiency marked.

July 1st : Manganese chloride plots probably slightly more vigorous than manganese sulphate ; ores probably some slight effect ; deficiency still marked on untreated plots.

July 11th : Foliage on all plots inclined to be pale and colour differences due to treatments not so marked as previously.

Vigour and colour markings gave the following results—
16 points possible for both growth and colour.

	MnSO ₄	MnCl ₂	Mn Ores	Untreated
Growth ..	12 $\frac{3}{4}$	14 $\frac{1}{4}$	11	10
Colour ..	12 $\frac{1}{4}$	13	9 $\frac{3}{4}$	8 $\frac{3}{4}$

July 29th : Beets were now being harvested by thinning best roots. The foliage on the sulphate and chloride plots was now developing deficiency symptoms and there had been some recovery from symptoms on the untreated and ores plots. It was difficult to distinguish between the treatments by foliage quality.

August 1st : In view of the condition on July 29th, Plot 2, one of the plots previously manured with manganese sulphate, was sprayed with a manganese sulphate spray, using 10 gallons of solution at a strength equivalent to 5 lb. MnSO₄ per acre.

August 20th : General condition of plots was as on August 1st. The sprayed plot, Plot 2, stood out from the remainder by its green, vigorous foliage, and it was obvious that the beets had responded markedly to the spraying treatment.

The observations in this experiment showed that the manganese sulphate and chloride soil applications were effective in supplying manganese during the earlier part of the growing period, whereas it is doubtful whether the ores, in which the manganese is present as manganese dioxide, was effective to any appreciable extent at any stage.

By July 11th both sulphate and chloride were becoming less effective, and by the end of that month these dressings were probably useless, as was shown by the spraying treatment on August 1st when manganese sulphate, used as a spray at 5 lb. per acre, was sufficient to restore healthy growth.

The great superiority of the spray was thus demonstrated and this was confirmed by further trials described below.

(b) Spraying Trials.

Two trials were carried out, one on a later sown batch of beets near the trial in (a) and the other in another district in Bristol.

In the first trial, treated plots were 1/120th acre (10 yds. $\times$ 4 yds.) and treatments were not replicated. Manganese sulphate and chloride were used at four rates, equivalent to 5, 10, 20 and 40 lb. MnSO_4 per acre, and 5 gallons of solution applied to each plot. Control plots, receiving water only, were included. The sprays were all applied with a watering can, fitted with a coarse nozzle, on July 1st, at which time the plants were half grown and were in a stunted condition and showing severe symptoms of manganese deficiency.

The plants responded markedly to the sprayings within ten days. The following notes show the subsequent events :—

July 11th : All Mn treated plots were in excellent condition ; water sprayed plants remained stunted and severely affected.

Marks given for healthy green colour were as follows (4 maximum) :

	5 lb.	10 lb.	20 lb.	40 lb.	Water.
MnSO_4 ..	4 -	4	4 -	4	1
MnCl_2 ..	4	4 -	4	4	1 •

It will be seen that all the manganese treatments had been entirely effective in bringing about the recovery of the plants.

July 29th : The 20 lb. to 40 lb. rates of both materials remained 100% efficient. On the 5 lb. and 10 lb. plots there were occasional palish leaves, but for practical purposes these were negligible.

August 20th : On all Mn treated plots, the foliage was vigorous and the roots well developed. On the water-sprayed controls the foliage showed some improvement but contrasted sharply with that on the Mn plots. There was a good yield of roots. On the 20 lb. and 40 lb. Mn plots there were a few affected leaves and symptoms were more common on the 5 lb. and 10 lb. plots, more so on the latter possibly due to soil variations.

The following conclusions were drawn :—

All the manganese treatments had been adequate to ensure healthy growth of the crops ; the 5 lb. per acre rate of manganese sulphate was sufficient for commercial control of the deficiency ; manganese sulphate and chloride were equally efficient when used as sprays at the rates tested.

In the second spraying trial the beets were in an advanced stage when the sprays were applied on July 17th, some roots having already been removed as thinnings for market. Manganese sulphate and chloride were again used at, 5, 10, 20 and 40 lb. per acre rates. Each spray unit measured 10 yds. by 8 yds. (1/60th acre) and 10 gallons of solution was applied to each plot, this rate of water being given to the control areas. The solutions were again applied from watering cans fitted with coarse nozzles. The 5 and 10 lb. treatments were in duplicate and the 20 and 40 lb. rates were on single plots. The deficiency symptoms at the time of treatment were very severe.

The effects of the treatments were examined in detail on July 29th, twelve days after spraying. All treatments had been entirely effective and the foliage on all Mn treated plots was vigorous and green. On the controls there had been a slight improvement, but they contrasted sharply with the treated plots.

The treatments continued to be effective until the last pulling was carried out in mid-August.

This trial again showed that 5 lb. per acre of manganese sulphate or equivalent chloride used as a spray is sufficient to effect a commercial control of the deficiency and that the treatment is effective when applied at a late stage of growth.

Summary.

1. The occurrence of manganese deficiency in the Bristol Province in 1941 is described and special mention is made of the problem in relation to the ploughing-out of grassland.

2. Experiments are reported on the use of manganese sulphate, manganese chloride and manganese ores (manganese dioxide), used as fertilisers, and on the use of manganese sulphate and chloride used as sprays, for the control of the deficiency in Globe Beetroot.

3. Manganese sulphate and chloride used as fertilisers at rates equivalent to 100 lb. MnSO_4 per acre were only effective in combatting the deficiency during the earlier stages of the crop. The ore used at a similar rate was practically ineffective at all stages.

4. Manganese sulphate and chloride were very effective as sprays when applied to half-grown plants or in the later stages of growth at rates between 5 and 40 lb. per acre. The former of these rates was sufficient for commercial control of the trouble.

Acknowledgments.

Messrs. J. O. Jones, H. E. Croxall and D. A. Osmond have been associated with the writers in these experiments.

Thanks are due to Mr. J. P. Inglis, City Forester, Bristol Corporation, and his staff, and to Messrs. J. & J. Brown, Ltd., Frenchay, Bristol, for their co-operation in the spraying experiments.

OBSERVATIONS ON THE CROPPING OF 10-ROD WAR-TIME ALLOTMENTS—SEASON 1941.

By E. W. HOBBS.

Introduction.

A detailed account appeared in the 1940 Annual Report of observations made on Six Demonstration War Time Allotments in the Bristol District.

Further records were obtained from these plots during 1941 and also from an additional three plots established in the spring of 1941.

The present report deals principally with the Horfield and St. Anne's plots and the particular allotment areas in which they are situated. Certain cultural problems emerged in the first year's working at these centres which it was hoped to overcome during the second season's cropping by special points of management. A note is also included on the Chapel Lane, St. George's, plot. Data relating to the remaining plots reveal no problems of sufficient importance for mention at this juncture.

Cropping Problems in 1940.

Horfield. This allotment area is one of very low fertility and this was reflected in poor results with most crops and many failures throughout the field.

The original turf was of poor quality and, although fairly free of perennial weeds, most plot holders insisted on peeling and burning the turf before breaking up the land.

Although digging was commenced late on the demonstration plot the turf was dug in with the top spit of soil, necessitating special attention to consolidation before seed sowing was carried out.

The demonstration plot received a dressing of 30 lb. superphosphate and 20 lb. sulphate of potash broadcast over the rough digging and 20 lb. of sulphate of ammonia as top dressings to crops, these comprising the total fertilizers applied during the year. This manuring, although causing marked improvement in crop yields compared with neighbouring unfertilized plots, was insufficient for satisfactory plant development. Failures resulted in the case of onions, swedes, turnips and summer spinach; small seed plant beds were a failure and transplanted brassicas were very slow in recovering from the move.

Due to the nature of the soil and no doubt also to the burning of the turf few plot holders in the area were able to maintain a satisfactory tilth during the summer months.

St. Annes. The whole area is severely infected with Potato Eelworm, and no satisfactory crop of potatoes was lifted in 1940. The yield on the demonstration plot was only 92 lbs. of Majestic from 36 lbs. of Scotch seed.

Management during 1941.

Horfield Plot.

Soil Preparation. With the exception of the area devoted to spring greens and sprouting broccoli the whole plot was given a thorough winter digging and the soil broke down admirably under the influence of the weather.

The applications of both phosphates and potash were doubled over those of the preceding year. 60 lb. superphosphate and 40 lb. of sulphate of potash being applied over the rough digging, and worked in during subsequent cultural operations. The amount of nitrogen used remained the same as in the first year, *i.e.* 20 lb. of sulphate of ammonia. and was applied mostly as top-dressings to growing crops.

In addition to the fertilizer dressing it was possible to dig in a fair dressing of composted material on the plot which had grown potatoes and roots and was in course of preparation for peas, beans, onions, etc.

Cultural Operations. The weather conditions experienced during 1941 were similar in some respects to those of 1940. In both years spring and summer were preceded by drought conditions which proved specially troublesome for the main transplanting of brassicas.

No water supply was available to water in any plants so that reliance had to be placed on firm beds, firm planting and constant hoeing in order to conserve moisture. Constant hoeing with the Dutch hoe was again made the basis, and in practice the plot was worked over once a week throughout the season, the operation in no case being made contingent on the presence of weeds.

Crop Yields. The cropping plan as set out in Growmore Bulletin No. 1, first edition, with slight modifications, was adhered to again in the second year.

It is possible therefore to treat crop yields for the two seasons on a comparative basis.

The appended table refers to the Horfield plot and shows the crop weights obtained from root vegetables, brassicas and other greens and leguminous crops which in the cropping plan are grouped mainly thus for the purposes of the simple three-course rotation recommended for the standard allotment plot. Onions are included in the root crop group for convenience, although in the actual crop rotation they are included in the same plot as peas, beans, etc.

Owing to the fact that crops such as kale, sprouting broccoli, leeks and spring cabbage were not harvested at the time of making out this report, crop yields refer, both for 1940 and 1941, to crops planted from spring onwards and harvested up to mid-December.

It will be seen that the greatest crop increase was obtained from the root crops, which included potatoes and onions.

The latter crop failed altogether in 1940, as did every other onion crop in the allotment field, and it is interesting to record that the only satisfactory onion crop grown in the particular area in 1941 was that on the Demonstration Plot.

Swedes and turnips were also failures in the first year, probably due to the lack of available phosphates, as revealed by characteristic leaf symptoms and confirmed by soil analysis. These crops failed to establish themselves in a manner typical of such conditions.

The phenomenal crop of parsnips harvested in 1940 was not repeated, but even so the crop lifted was highly satisfactory.

Unharvested crops growing on the plot at the time of compiling this report included a few savoys, a further picking or two of Brussels sprouts and tops, two rows each of curled kalé and of purple sprouting broccoli, a row of

perpetual spinach beet, a bed of leeks (150 plants), and five rows of spring cabbage. Each row of plants measures 20 feet in length.

St. Annes.

Potato Eelworm. Under normal peace-time conditions one would recommend that no potatoes should be grown on these allotments for some years. Plot holders, without exception, however, continued the planting of potatoes in 1941 in spite of complete failure due to eelworm in the previous year. For this reason it was decided to plant potatoes again on the demonstration plot and to treat the crop on lines already well known for the mitigation of eelworm damage.

Soil Preparation and Planting. An early potato, Arran Pilot, was chosen for planting. The plot was well cultivated and prepared, and the manuring prior to planting consisted of 2 oz. of sulphate of ammonia per sq. yd. in addition to the basic phosphatic and potassic dressings recommended for the whole plot, *i.e.* 30 lb. superphosphate and 20 lb. sulphate of potash.

Thirty-six pounds of well sprouted tubers were set out in early April. A top-dressing of sulphate of ammonia, 2 oz. per sq. yd., was lightly forked between the rows when the plants were 2 inches high, and this dressing was repeated three weeks later.

In all the potato crop thus received 6 oz. of sulphate of ammonia per sq. yd. or about 15 cwt. per acre—an extremely high figure under ordinary conditions.

Crop Yield. The potato haulm developed satisfactorily and showed little of the typical dying back of foliage associated with eelworm. The crop was dug in stages, the last tubers being harvested in late August. The total yield was 264 lb. compared with 92 lb. in 1940. Very few tubers were below "ware" grade and the potatoes cooked perfectly for table use.

Although the yield was not a heavy one it was a marked advance on that of the previous year and also stood far above any crops harvested nearby.

Chapel Lane, St. Georges.

Symptoms of slight manganese deficiency again appeared on beetroot and summer spinach on this plot, but the yield of beetroot was trebled during 1941 from the same number of rows grown in the previous year, *i.e.* 36 lb. as against 12 lb. in 1940. Summer spinach was not grown.

One half of the allotment was dressed with magnesium sulphate throughout its length, but it was impossible to attribute any benefit during the growing season from this application.

The weight of produce harvested during 1941 from this allotment showed an increase of approximately 30% (1,006 lb. as against 773 lb.) over that harvested during a similar period in the previous year. No great increase, however, was obtained from the Brassica crops, and this may be due in part to the continued poor response obtained from the use of nitrogenous top-dressings on this plot. Spring cabbage was an exception, the weight cut during the spring of 1941 being 112 lb., which was much greater than that produced by any of the other demonstration allotments under the control of the writer.

Discussion.

The results obtained on the Horfield plot show what can be done by suitable management to overcome soil difficulties. The plot produced approx. 28% more food during a comparable period in 1941 than it did in 1940, the greatest increases being in crops capable of storage.

Group I (potatoes, roots and onions) accounted for approx. 70.7% of the vegetables produced in the three groups, Group II (Brassicas and other greens) approx. 20.5%, and Group III (Legumes) approx. 8.6%.

Transplanted plants of Brassicas made a much quicker recovery than was the case in the previous year and small plants developed more satisfactorily in the seed beds.

The influence of the decaying turf on tilth was still apparent, and its benefits were very obvious when comparing the demonstration plot with other plots on which the turf was burned.

The demonstration plot again produced useful crops of vegetables in an area where failures of poor crops were numerous and the difference in development between plants on the demonstration plot and those on neighbouring allotments was even more marked than in the first year.

The potato crop at St. Annes demonstrated what can be done where potatoes must of necessity be grown in the presence of heavy eelworm infestation. The amount of nitrogen applied would normally be considered excessive, but no doubt the retarding effect of eelworm infection prevented the whole of this being used. The possibility of spoiling the cooking and edible qualities of potatoes grown under such treatment must be borne in mind, although in this instance no bad effects resulted.

The Chapel Lane Plot and the surrounding allotments provide some interesting problems in addition to manganese deficiency. Crops rarely appear in what might be termed, to use a gardener's phrase, a "happy" state. Leaf development is often quite second rate and healthy deep green colours are rarely noted. It is possible that the ash and general garbage refuse of which the top soil is now largely composed has some toxic effect on plant growth due to the presence of heavy metals. It has been shown that the soil contains abnormally high amounts of zinc, copper and nickel.

These considerations, however, are not of sufficient magnitude to reduce crop yields seriously, and what was a most unpromising and seemingly undesirable site has proved capable of contributing substantially to the Growmore Food campaign.

Acknowledgments.

The writer is indebted to Messrs. C. H. Gibbons, Horfield; R. Bowditch, Chapel Lane; and F. R. Davies, St. Annes; for the efficient manner in which they carried out the cultivations and recording on their respective plots.

CROPPING TABLE HORFIELD DEMONSTRATION ALLOTMENT. SEASONS 1940-1941.

CROP YIELDS IN LB. OF VEGETABLES GROWN WITHIN THE ROTATION GROUPING, *i.e.* POTATOES.
ROOTS (ONIONS INCLUDED HERE); BRASSICAS AND OTHER GREENS; LEGUMINOUS CROPS.

	Crop	1941 Yield in lb.	1940 Yield in lb.	Increase or Decrease lb.
<i>Group I.</i> Potatoes and Roots (Onions included here).	Potatoes	431	344	+ 87
	Parsnips	93	148	— 55
	Carrots	216	70	+ 146
	Swedes	21	failure	+ 21
	Turnips	31	"	+ 31
	Beetroot	41	6	+ 35
	Onions	70	failure	+ 70
	Totals Crop increase	903	568	+ 335
<i>Group II.</i> Brassicas and other Greens.	Brussels	51	30	+ 21
	Sprouts			
	Cabbage	42	30	+ 12
	Cauliflower	44	24	+ 20
	Savoy	80	120	— 40
	Spinach Beet	20	12	+ 8
	Lettuce	25	16	+ 9
	Totals Crop increase	262	232	+ 30
<i>Group III.</i> Legumes.	Broad Beans	18	7	+ 11
	Dwarf Beans	30	30	0
	Runner Beans	33	31	+ 2
	Peas	30	8	+ 22
	Totals	111	76	
	Crop increase			+ 35

GARDEN TRACTORS.

I. TYPES AND ROUTINE MAINTENANCE.

By H. G. H. KEARNS.

Small tractors of the types where the operators walk behind are generally referred to as garden tractors. These tractors are designed with a view to meeting the requirements of growers whose acreages do not justify the expense of larger models and on whose holdings there is a need to reduce the amount of hand labour to a minimum. The outfits are expected to be of general utility and suitable for ploughing, row crop work, driving small spray pumps, light haulage, etc. Many of the machines are built to sell at a moderate price and this does not always permit the best of engineering design or the fitting of refinements. Although the outfits are relatively small in size they require skilful handling and as a rule they cannot be handled in a satisfactory manner by women or lads. The ease of handling depends largely on an adequate power output at low travelling speeds and the provision of independent wheel clutches and/or a differential, to reduce the great physical effort required to turn on narrow headlands.

The machines are of two distinct types. The majority have two main driving land wheels and attached to the chassis is a tool bar frame to which are fitted a conventional range of tools, namely: steel points, hoes, sweeps, furrowers, ridgers, hillers, etc. A plough may be fitted after removal of the cultivating frame and the track can be adjusted by moving the wheels on the axle. This all purpose tractor demands some mechanical skill and a proper understanding of the tools to obtain the optimum results.

The second type of outfit depends on rotary cultivation. Generally a rotor, to which are attached hoes and tynes, cuts into the soil and the land wheels perform the duty of assisting the forward motion of the machine. The machines in which the land wheel and rotor speeds have several gear ratios are able to produce in one operation a soil condition which approximates to that resulting from separate ploughing, discing and cultivating. Rotary cultivation is not well suited for soils with fairly large or numerous stones or which are badly infested with couch or other weeds with long stolons or roots. There is some unjustified prejudice against this form of cultivation mainly because too fine a tilth is obtained by incorrect selection of gears. By adjusting the depth of the rotor in the soil a range of cultivation from very shallow to deep can be obtained and weed control is most satisfactory. The machines are of fixed track and cannot be straddled over rows: therefore planting distances between rows must be of sufficient width to accommodate the machine, and up to three feet may be necessary for easy working. Ridgers and hillers can be fitted to some models.

Steel-cleated or rubber-tired wheels may be obtained with both types of tractor. The steel type are preferable on the normal type as they provide better traction. Either type is satisfactory on the rotary type as the action of the rotor assists the forward motion of the machine.

Too much is often expected of garden tractors; the machine of sufficient power for efficient ploughing and heavy cultivations is often too cumbersome

and heavy for inter-crop cultivations of many closely planted market garden crops. The best results are obtained by using two machines, a larger model for heavier work and a very small machine to replace extensive hand or push wheel hoeing.

Unfortunately the importance of clean air and fuel and of efficient lubrication is not fully appreciated. The garden tractor works under the most arduous conditions and its efficiency can only be maintained by careful attention to the above points. With many outfits the margin of spare power is small and therefore should not be decreased by faulty maintenance.

Air. The greatest enemy of agricultural machinery is dust from the soil which, with oil, forms an efficient grinding paste. Many bearings on farm machinery are inadequately protected against the entry of dust and rapid wear results.

The petrol engine sucks in for combustion very large quantities of air and it is of the utmost importance that this air is dust-free in order to avoid extremely rapid wear. In the four stroke engine the wear may be particularly noticeable in the cylinder bore, piston rings and valve stems, but in the two stroke engine in which the fuel enters the crank case the wear extends to main shaft and big end bearings. It is no exaggeration to state that most agricultural two stroke engines are worn out by dirty air and not by hard work.

Air cleaners are now fitted to engines by most makers of garden tractors. Often, however, the size of the cleaner is so small that on dusty soils it requires cleaning about every two hours of running to ensure that it is even moderately effective. A partially choked cleaner upsets carburation. The small, dry, plain, fine gauze type of cleaner is useless and the oil-wetted gauze type is little better unless of very large surface area. It is essential that a very large cleaner is fitted, preferably of the vertical, corrugated, special felt type or an oil trap type. The sizes recommended by the makers of air cleaners as suitable for an engine of given combustion volume capacity, working under normal road conditions, should be doubled or trebled. The cleaner should be fitted in a position that avoids dust as much as possible, *i.e.* out of the flow of dust agitated by the land wheels and exhaust pipe gases. An unsatisfactory type can, in most cases, be replaced and fitted fairly readily by means of flexible metallic tubing or rubber hose, suitable adaptors, supports and hose clips. The detachable felt element in the cleaner should be cleaned regularly by washing out in petrol or by blowing through from the inside surface with compressed air and once each season the element should be renewed as the cost is infinitely less than that of an engine overhaul. Oil filters should be washed out with petrol or paraffin and refilled with engine oil after every eight hours of running.

Fuel. The petrol should be poured into the tank through a funnel fitted with petrol gauze as this will ensure freedom from irritating stoppages from choked jets and filter gauzes.

Lubrication. A new or rebored engine should be run in on a light load for 30 hours and the addition of colloidal graphited oil to the lubricating oil for the first 60 hours of running minimises the risk of a seizure and enables the working parts to bed down. It is recommended that colloidal graphite be used throughout the life of two stroke engines, particularly those lubricated by the addition of the oil to the petrol. Graphited oil should be shaken well

before pouring out. Only the best oil of a suitable grade should be used and both under and over lubrication avoided. The oil in the sump or circulation reservoir of four stroke engines should be changed every 40 hours of running. Oil filters if fitted should be washed in petrol every 100 hours and the element replaced at the recommended intervals or earlier if it appears faulty. Care should be exercised to keep the oil measure absolutely clean from dirt and after use it should be covered with a clean cloth. It is inadvisable to wash out the engine sump or reservoir with paraffin and petrol unless precautions are taken to drain out the last few drops as both solvents are dangerous oil diluents.

The gear box, when present, should not be forgotten and the oil changed after every 200 hours of running. In this operation it is advisable to flush out the case with paraffin and the engine should be run in and out of gear as this procedure removes congealed oil. The paraffin should be allowed to drain away completely before refilling the box with the correct oil.

The oil in the engine sump and gear box should be drained out when hot.

In some models, gears, dog clutches, shaft bearings, etc., are lubricated by oil guns. The best lubricant in most instances is one of the extreme pressure lubricants and not grease. The oil nipples should be cleaned before applying the gun and it is wise to ensure that the gun is ejecting lubricant, as quite often no lubricant enters the bearing due to a faulty nipple or gun. Any undue resistance in the injection stroke indicates that there is a blocked oil channel or a faulty nipple. A blockage can often be cleaned by sustained pressure and a faulty nipple should be replaced by a temporary removal of a sound one from another point. Little or no resistance in the gun usually indicates an air lock in the barrel of the gun, which may be relieved by pulling out and re-inserting the leather washer to which a chain is usually attached. In very cold weather too viscid an oil may be the cause of the trouble and this may be overcome by pausing between the injection strokes or using a thinner grade of gear oil.

If a bearing is a plain, unprotected type and carries an exposed shaft, such as the main land wheel shaft on some machines, it is wise to force some of the lubricant out as this ensures the removal of some of the dirt which finds its way into the bearing.

If chains are used in the transmission they should be lubricated with light graphited oil regularly and if fitted in cases the correct oil level should be maintained.

An oil can filled with thin oil should be applied to appropriate parts taking care to wipe away excess oil and accumulated dirt. Points which require regular attention include the wheel shaft extension of tractors fitted with adjustable track, the splines on the shaft bearing sliding dog clutches, the thrust bearing of plate clutches, the bearings of rotor shafts, the joints of control rods, the engagement pin of starting handles, etc. It also pays once a year to lubricate the inner cable of Bowden controls, which is best done by detaching the nipple from a control lever and when holding the outer cable vertically feeding in about 20 drops of thin oil at the point where the inner cable enters the outer.

The rule for satisfactory lubrication is little and often.

Ignition.

Sparking plugs should be regularly cleaned and the correct gap between the ignition points maintained, usually 18 thousandths of an inch. All carbon should be removed by gentle scraping by means of the tail end of a small file: on no account should the points be filed. The best method of cleaning is by compressed air blasting but this means is not often available. Plugs in which the central electrode can be removed should be used to facilitate cleaning as two stroke engines frequently oil up and deposit carbon deep in the cavity of the plug body. One piece plugs are more efficient but impracticable for garden tractor engines.

The performance of many engines is markedly affected by the type of plug fitted and it is well to adhere to the engine makers recommendation.

Two stroke engines place a severe strain on the insulation of sparking plugs and it is wise to fit a new one each season or after 300 hours of running. A protected terminal is recommended as it prevents shorting in wet weather.

All types of modern garden tractor engines are air cooled. The cylinder head and barrel is submitted to a draught of air from some form of turbo fan driven off an extension of the crankshaft or forming part of the flywheel. It is important to keep the cylinder head as clean as possible to ensure efficient radiation of heat. A stiff brushing will remove most of the dust. The inlet aperture of the cover of the blower or fan sometimes becomes blocked with leaves, roots, etc., and this restricts the airflow and overheating of the head occurs.

Care of Implements.

Each model of tractor, using conventional cultivating tools, requires experience with it to obtain the best results. Often the recognised method of setting a plough requires modification. When the best set for a plough and other implements is obtained the positions of the adjusting bolts should be noted preferably by marking with a file cut. A few drops of thin oil on the thread of bolts, threaded adjustment wheels and rods is well worth while as it ensures ease of movement.

The cultivating tool frames vary in design but several consist of square or rectangular section longitudinal and cross bars kept in position by clasp clamps, the same method of attachment being frequently employed for the tool stalks. The number of and the depth of the tools fitted to the frame must be adjusted so that the engine is not overloaded. The tools should be spaced so that the load is even on each side of the tractor otherwise it will refuse to pull straight. The spacing must also be adjusted so that the broken soil and weeds are able to clear away from the tool points.

The bearing of the depth wheel presents a lubrication difficulty. It is working under particularly arduous conditions and the entry of dirt into the bearing cannot be prevented unless this is of an expensive design. It usually consists of a spindle running in a cast iron wheel. The addition of oil prevents an irritating squeak but it forms an efficient grinding paste with the soil. Rapid wear of this bearing must be accepted as unavoidable. Unfortunately the makers often omit to make provision for the rebushing of the wheel and easy replacement of the spindle, and therefore a new wheel and stalk must be purchased. A badly wobbling wheel or wheels is often the cause of difficulty in steering straight in row crop cultivation.

When adjustments are made to cultivating implements undue force should not be used; thus the common practice of hammering the head of tool stalks burns the ends and causes subsequent difficulties in sliding through the clasp clamps. The threads of the clasp clamp and other bolts should be kept oiled as this ensures ease of fine adjustments.

The edges of heel steels, sweeps, etc., should be kept keen by grinding, and omission of this point markedly reduces the efficiency of a cultivation.

The hoe blades on some rotary cultivators should be set at a slight angle to the earth surface. After prolonged use the hoes gradually bend until they are horizontal and this set of position places a wasteful load on the engine. The hoes should be removed, heated and bent to the angle of the original set, and the cutting edges ground.

A SUMMARY OF FRUIT SPRAYING PROGRAMMES. 1942 REVISION.

By H. G. H. KEARNS and R. W. MARSH.

In the 1936 Annual Report of the Long Ashton Research Station (pp. 75-89) the authors published a programme designed to provide a spray time table for commercial plantations in the Bristol Province. The lapse of six years has rendered this programme out of date in certain respects and a revision has become necessary. It was first intended to publish a list of amendments and additions to be read in conjunction with the 1936 article, but such a list would be complicated in use and not readily intelligible. It has therefore been decided to reproduce the whole programme in a revised form, incorporating all the necessary corrections. This necessitates the inclusion in the present article of much material already published in the 1936 programme but no other way of presenting the facts clearly and concisely seems applicable.

The principal reasons for the issue of a revised programme are the introduction of new spray materials and changes in the recommended concentrations of sprays already well known. The most important advance has been in the introduction commercially of dinitro-ortho-cresol petroleum washes. These have a wider range of toxicity than tar oils and so render unnecessary the separate application of tar and petroleum washes and reduce the need for lead arsenate. They find application on a wide range of fruit crops.

The strength of lime sulphur originally recommended for control of Big Bud Mite on currants has now been proved unnecessarily high. A lower concentration reduces the risk of sulphur injury and decreases liability to subsequent frost injury. Lime sulphur injury to apples, although the subject of investigation, is still far from being completely understood and experience in each orchard is the only sure method at present of selecting a safe concentration.

The spray programmes are to be taken as guides and they may have to be modified to suit local conditions both in regard to the composition of spray mixtures and times of applications. Each orchard presents its own problems due to differences in varieties, soil conditions, climate and management.

If further particulars of individual pests, diseases or materials are required, the reader is referred to the papers listed at the end of the 1936 article.

The spray programmes described concern the following plants:—

- | | |
|------------------|------------------|
| I. Apple. | VII. Gooseberry. |
| II. Pear. | VIII. Raspberry. |
| III. Plum. | IX. Loganberry. |
| IV. Cherry. | X. Blackberry. |
| V. Blackcurrant. | XI. Strawberry. |
| VI. Redcurrant. | |

I.—APPLE.

	Stage.	Approximate date of Spraying.	Materials per 100 gallons water .	Pests and Diseases Controlled.
1	Dormant	Dec.-mid. Feb.	4-7½ gall. tar oil emulsion	Aphides Sucker (<i>P. mali</i>)
2	Delayed dormant	Late March	6-7½ gall. petroleum oil emulsion	Capsids (<i>P. rugicollis</i> and <i>L. pabulinus</i>)
or 2a	„	Up to mid-March	or, in place of (1) & (2), 4-7½ gall. DNOC petroleum oil emulsion	Red Spider (<i>O. ulmi</i>) Winter Moths Aphides, Sucker and Capsids
3	Greenflower	April 15—25	3 gall. lime sulphur	Scab
4	Pink Bud	May 1—8	2½-3 gall. lime sulphur 2 lb. lead arsenate powder or equivalent	Scab Tortrix Winter Moths
5	80 per cent. Petal-fall	May 18—30	8 oz. nicotine ½ lb. wetter† or 1 gall. white oil emulsion	Sawfly Capsid
5a	7 days after stage 5		8 oz. nicotine ½ lb. wetter† ¾-1 gall. lime sulphur	Sawfly Capsids Red Spider Scab
6	3 weeks after petal-fall	June 15—22	¾ gall. lime sulphur	Scab
7	1st Codling Cover Wash	July 1—10	3 lb. lead arsenate powder 1 gall. white oil emulsion	Codling Moth

† e.g.—the proprietary water-soluble wetters Agral 2 or Lethalate Wetting Preparation or Sulphonated Lorol, or 1 qt. 20 per cent. Ester Salts.

NURSERY STOCK.				
1	Delayed dormant	Up to mid-March	7½ gall. DNOC petroleum oil emulsion	Aphides, Sucker Red Spider Capsids
5	Equivalent to petal-fall of mid-season flowering varieties	May 18—30	8 oz. nicotine 1½ gall. white oil emulsion	Winter Moths Aphides Woolly Aphid Red Spider Capsids
6	3 weeks after petal-fall	June 15—22	8 oz. nicotine 1½ gall. white oil emulsion	Woolly Aphid

Specification for Materials.

Tar Oil Wash. The tar oil wash should conform to the specification of the Ministry of Agriculture and the Association of British Insecticide Manufacturers and be diluted according to the maker's instructions.

Petroleum Oil Wash. High boiling petroleum oils conforming to the specification of Grade E are recommended at a concentration of not less than 5 per cent. to ensure a satisfactory control of capsid bugs.

Combined Tar Oil-Petroleum Washes. The combined wash must be applied at a concentration that ensures the minimum amount of tar and petroleum oils stated above.

White Oil Emulsion. A white oil emulsion for summer use should be prepared with an oil conforming to specification G. An oil of unsulphonated

residue of less than 90 -92 should not be used after the delayed dormant stage. If the emulsion is used with lead arsenate or lime sulphur it should be emulsified with sulphite lye. The oil emulsion concentrate quoted in the programme contains 66 per cent. oil.

Dinitro-ortho-cresol Emulsion. A combined wash of dinitro-ortho-cresol and petroleum oil (Grade E). The wash should be applied at a concentration of 0.1 per cent. DNO₂C and 3 or 5 per cent. oil. The lower concentration of oil is sufficient for Red Spider control but 5 per cent. is necessary for capsid bug and caterpillar control. These concentrations are approximately equivalent to 4 and 7½ per cent. respectively of some proprietary washes.

Lead Arsenate. Lead arsenate may be used in powder, paste or colloidal form. The colloidal material if used in conjunction with lime sulphur may result in foliage damage. For this purpose the amount of lead arsenate should be equal to 2 lb. in dry weight ; 4 lb. of paste and 1 quart of colloidal arsenate are each equivalent to 2 lb. powder.

The remainder of the materials with the exception of proprietary products should conform to the standards laid down by the Ministry of Agriculture and Fisheries.

Alternative Spray Materials.

Combined Tar Oil Petroleum Wash. Although the separate applications of tar and petroleum emulsions or a D.N.O.C. petroleum emulsion are the best means of ensuring control of a severe infestation of capsid bugs, there are times when a combined tar oil-petroleum wash may be preferred. A wash of this type is used at high concentration of oils and must be applied not later than mid-February in order to reduce the risk of bud damage. The wash does not always provide a satisfactory control of Red Spider (*O. ulmi*) but ensures an effective control Winter Moth (*C. brumata*).

Bordeaux Mixture. Bordeaux mixture may be used pre-blossom instead of lime sulphur on varieties not copper-sensitive (see under). If a copper spray is required for use in mixed washes it is preferable to employ a spray made up of 8 lb. copper sulphate and 12 lb. hydrated lime per 100 gallons water.

Supplementary Control Measures.

Winter Moth. The combination of efficient winter washing and the pre-blossom applications of lead arsenate generally provides a satisfactory control of the larvae of the Winter Moth. In some circumstances grease banding may be preferred. The banding should be carried out in October and the grease regularly raked over from early November until late December, the period that coincides with the emergence of the majority of the moths.

Blossom Weevil. Applications of Derris or Lonchocarpus dusts at the early green-flower stage do not provide a sufficiently high control to warrant the expense. Sack banding applied to the boles of the trees in June at times provides a means of capturing large numbers of weevils. It is desirable that the bands be removed from the trees before the end of October, and the weevils killed by immersing the sacking in Derris wash. If the removal of the bands is postponed until later many of the weevils will leave and find fresh hibernating quarters in hedgerows, etc., well away from the tree.

Codling Moth. Sack banding applied to smooth-barked trees at the times mentioned above for Blossom Weevil provides a means of capturing large numbers of Codling larvae. On older trees the larvae hibernate beneath the rough bark in preference to beneath the sacking, and therefore rough bark must be removed by means of a scrape before applying the bands.

Modifications for Variation in Pest and Disease Intensity.

Winter Moth and Tortrix Moths. Lead arsenate may be omitted from the pink bud stage lime sulphur wash if DNOC or other winter washes containing 5 per cent. of petroleum oil have been applied for a number of seasons. Winter washes fail to give a high control of Tortrix Moths and it is wise to add lead arsenate to the pink bud wash every third season to keep these pests under control.

Apple Sawfly. Double spraying (5 and 5a) is strongly recommended when the sawfly infestation is severe. If the infestation is not serious or it is impracticable to double spray the following single application of a combined wash may be given at stage No. 5.

8 oz. nicotine.

1 lb. or $\frac{1}{2}$ gall. wetter. (See Table I.)

1 gall. lime sulphur.

100 gall. water.

The lime-sulphur must be omitted on sulphur-shy varieties and it should be replaced by one gallon of a refined petroleum emulsion to ensure a control of Red Spider. If oil emulsion is used the wetter must be omitted.

Codling Moth. Nicotine sulphate 20 fl. oz. per 100 gall. is suggested as a substitute for lead arsenate on very early varieties, such as Beauty of Bath, in order to avoid the risk of excess arsenical residues on the fruit at the time of picking. A second cover wash applied at the end of July may be necessary to control severe infestations. It should consist of nicotine sulphate and white oil emulsion (non-alkaline) and only be applied to late varieties.

Scab. Application 6 is necessary only in wet summers or where scab attack is unusually heavy.

Modification of Programme for Varieties.

Copper-sensitive varieties, such as Cox, Grieve, Worcester, should not be sprayed with Bordeaux mixture or any other copper fungicides after April.

Sulphur-sensitive varieties, such as Stirling Castle and Lane's Prince Albert cannot be treated with any form of sulphur after blossoming without risk of damage.

II.—PEAR.

	Stage.	Approximate date of spraying.	Materials per 100 gallons water .	Pests and Diseases Controlled.
1	Dormant	Dec.-mid-Feb.	4-7 $\frac{1}{2}$ gall. tar oil emulsion	Aphid
2	Delayed dormant	End of March	3 gall. lime sulphur	Scab
3	Greenflower	Mid-April	3 gall. lime sulphur	Scab
4	White-bud	End of April	2 lb. lead arsenate powder 1 gall. lime sulphur	Winter Moths Scab
5	Petal-fall	Mid-May	2 lb. lead arsenate powder 1 gall. lime sulphur	Winter Moths Scab
6	3 weeks after petal-fall	End of May	1 gall. lime sulphur	Scab
7	6 weeks after petal-fall	Mid-June	1 gall. lime sulphur	Scab

Specification of Materials.

See apple programme.

Alternative Spray Materials.

Dinitro-ortho-cresol petroleum emulsion may be used instead of tar oil. Bordeaux mixture may be used instead of lime sulphur.

Other Control Measures.

Winter Moth. As Winter Moth is frequently a serious pest of pears, grease banding should be carried out in those orchards subject to severe infestations. A D.N.O.C. petroleum wash as recommended for capsid control on apples may be applied for aphids, capsid and caterpillar control. This renders grease banding unnecessary and in many instances lead arsenate need only be added to the white bud wash (No. 4).

Capsid Bugs. The Capsid Bugs (*P. rugicollis* and *L. pabulinus*) are both responsible for corky markings on pears. The capsids must be controlled not later than petal fall, and this control may be obtained by the addition of 8 oz. of nicotine and $\frac{1}{2}$ lb. water-soluble wetter (as described for apple pests) in spray No. 5. Grease banding just before the petal-fall application may be used in special cases, or if grease bands are already on the trees, they should be combed over to expose a fresh surface. The banding material prevents the ascent of capsids which often wander from other host plants.

Pear Slugworm or Sawfly. This pest can cause rapid and serious defoliation, particularly in young plantations. There are two principal broods. The first brood of larvae is easily controlled by the addition of 2 lb. lead arsenate powder to wash No. 6. The second brood is best controlled by the application in mid-July of a wash containing 6 oz. nicotine and $\frac{1}{2}$ lb. of wetter to 100 gallons of water, or $1\frac{1}{2}$ lb. Derris or Lonchocarpus root (containing not less than 1.5 per cent. crystalline rotenone) may be substituted for the nicotine.

Pear Midge. This pest may be considerably checked when the trees are grown on light soil by the application in March of calcium cyanide to the ground at the rate of $\frac{1}{2}$ oz. per square yard.

The addition of 8 oz. nicotine and $\frac{1}{2}$ lb. wetter to the "white bud" wash is also worthy of trial. The application must be made as soon as the first portion of white colour appears on the flower buds.

Codling Moth. The control measures recommended for apples may be applied.

Remarks.

The number of applications of fungicidal post-blossom washes is determined by the intensity of the scab attack: in general, scab of pears is more difficult to keep in check than that of apples.

The variety Doyenne du Comice is subject to both copper and sulphur injury when sprayed after petal fall.

III.—PLUM.

	Stage.	Approximate date of spraying.	Material per 100 gallons water.	Pests and Diseases Controlled.
1	Dormant	December to mid-January	4-7½ gall. tar oil emulsion	Aphides
1a	"	Up to mid-Feb.	or 4-7½ gall. D.N.O.C. emulsion	Aphides
2	"Cots" splitting	May 10—20	Derris (see under) 1 gall. white oil emulsion	Red Spider Winter Moths Plum Sawfly Winter Moths Red Spider

Specification of Materials.

For tar oil emulsions, dinitro-ortho-cresol emulsions, white oil emulsions, lead arsenates, and wetters see apple programme.

Derris. The amount of Derris or Derris extract required depends on the rotenone content. The wash should contain not less than 0.004 per cent. of crystalline rotenone.

Alternative Spray Materials.

Lonchocarpus or any other rotenone-containing material may be used as a substitute for Derris provided it is suitable for use with a white oil emulsion.

Supplementary Control Measures.

The control of Winter Moths is important on plums, and it may be obtained by the application of D.N.O.C. petroleum emulsion (see apples). The 5 per cent. concentration of petroleum oil is recommended for one or two seasons until Winter Moth control is satisfactory, after which 3 per cent. oil is sufficient. If tar wash is used grease banding is important and the band should be carefully applied to ensure that all the crevices of rough bark are included. The grease must be regularly combed during the period of early November to the end of December.

The pruning of plum trees during autumn is to be avoided since the likelihood of infection by silver leaf and bacterial canker is then at its greatest. In glut years fruit should not be left on the trees nor should fruit be permitted to rot undisturbed because this procedure increases the risk of brown rot.

The Wood Scolytid Beetles (Wood Borers) are not primary pests of the tree, but their presence invariably indicates that the tree is in a low state of vigour due to unsatisfactory soil or manurial conditions, or as a result of over-cropping or following severe loss of foliage by insect attack.

Modifications for Pest and Disease Intensity.

If there is any doubt of the timing of the spraying for the control of Plum Sawfly or the spraying is indifferent, two applications of the Derris petroleum wash should be applied at an interval of a week.

If Plum Sawfly is absent it will still be necessary to spray for the control of Red Spider unless a Dinitro-ortho-cresol petroleum wash has been applied. Either a white oil emulsion or 1 gallon lime sulphur with ¼ lb. wetter per 100 gallons should be applied after the "cots" have split. If Winter Moth larvae are prevalent lead aesebate may be added to the Red Spider wash. In some seasons of severe caterpillar infestation it may be necessary to apply the lead arsenate in early May.

Modifications of Programme for Variety.

Victoria and other loose-scaled varieties are more subject to tar oil injury and should therefore be sprayed if possible before Christmas.

Early Rivers is sulphur-sensitive ; Purple Pershore is subject to arsenical injury and a combined lime sulphur and lead arsenate wash cannot be safely applied to this variety.

IV.—CHERRY.

Stage.	Approximate date of spraying.	Material per 100 gallons water.	Pests and Diseases Controlled.
Dormant	Dec.-Jan.	4-7½ tar oil emulsion	Aphid
Delayed dormant	Dec.-mid-Feb.	7½ gall. D.N.O.C. emulsion	Aphid, Caterpillar
Mid-season	Mid-June	Derris (see under)	Cherry Sawfly
		½ lb. wetter	(1st Brood)
Late season	August	2 lb. lead arsenate powder or equivalent	Cherry Sawfly
		¼ lb. wetter	(2nd Brood)

Specification for Materials.

For tar oil emulsion, D.N.O.C. emulsion, Derris and wetter see apple and plum.

Supplementary Control Measures.

Winter Moths may be controlled by D.N.O.C. petroleum emulsion or by supplementing the tar oil emulsion, and by means of efficient grease-banding (see plum).

Modifications for Pest and Disease Intensity.

If grease-banding is omitted or D.N.O.C. emulsion is not applied and caterpillar attack proves serious, it is necessary to apply a lead arsenate wash in spring, not later than the first week in May.

Cherry Sawfly (*Eriocampa limacina* Cameron). It is desirable to control the first brood of larvae in June by means of a Derris wash in order to avoid any poisonous deposit on the fruit. The second wash can often be omitted if the first spraying is carried out efficiently.

V.—BLACK CURRANT.

	Stage.	Approximate date of spraying.	Materials per 100 gallons water.	Pests and Diseases Controlled.
1	Dormant	Dec.-Feb.	4-7½ gall. tar oil emulsion	Aphid only
or 1a	Just prior to bud burst	Mid-end Feb.	10-12 gall. tar oil petroleum emulsion	Aphid, Capsids Winter Moths
or 1b	Just prior to bud burst	„	7½ gall. D.N.O.C. petroleum emulsion	Aphid, Capsids Winter Moths
2	Tight cluster*	Early April	4 gall. lime sulphur ½ lb. wetter	Big Bud Mite
3	Immediately after picking	Mid-end July	Bordeaux mixture made with 8 lb. copper sulphate 12 lb. quick lime ¼ lb. wetter	Black Currant Leaf Spot

* Flower buds on raceme unopened and clustered.

Specification of Materials.

For tar oil, D.N.O.C., tar oil-petroleum and wetters see apple.

Alternative Spray Materials.

12 lb. high grade hydrated lime may be substituted for 8 lb. quick lime.

Copper oxychloride or cuprous oxide wash at 4 lb. per 100 gallons water or copper-lime dust may be used for application 3.

Supplementary Control Measures.

Reversion can be materially checked by planting only material from a disease-free source.

Modifications for Pest and Disease Intensity.

The combined wash of tar oil-petroleum (1a) or D.N.O.C. petroleum (1b) is essential when capsid bugs are present as pests.

Modifications of Programme for Varieties.

The post-cropping application of Bordeaux mixture is specially desirable on the Baldwin and Boskoop varieties which are highly susceptible to leaf spot (*Pseudopeziza ribis*). Varieties belonging to the Edina group, e.g. Victoria, Monarch, Goliath, are subject to sulphur injury, particularly if frost follows or coincides with the application. Not more than 2 per cent. concentration of lime sulphur can be safely applied to these varieties. Davison's Eight is very sensitive and it is not safe to apply lime sulphur to this variety at a concentration above 1 per cent.

VI.—RED AND WHITE CURRANTS.

A programme similar to that for black currants is recommended. The concentration of lime sulphur should be reduced to 2 per cent.

VII.—GOOSEBERRY.

	Stage	Approximate date of spraying.	Materials per 100 gallons water.	Pests and Diseases Controlled.
1	Dormant	Dec.-Feb.	4-7½ gall. tar oil emulsion	Aphides
or 1a	Before bud-burst	Early to mid-February	10-12 gall. tar oil-petroleum wash	Aphides Capsids Winter Moths Gooseberry Red Spider
or 1b	Before bud-burst	Early to mid-February	7½ gall. D.N.O.C. emulsion	Aphides, Capsids Winter Moths
2	Fruit-setting	Late April	Sulphur dust	American Mildew
3	3 weeks after fruit-setting	Mid-May	Sulphur dust	American Mildew
or 3a	End May	End May	Derris (see under) ½ lb. wetter 1 gall. lime sulphur	Gooseberry Sawfly (1st brood) American Mildew
4	End June	End June—early July	Derris (see under) ½ lb. wetter	Gooseberry Sawfly (2nd brood)

Specification of Materials.

For tar oils, tar oil-petroleum and D.N.O.C. petroleum oil washes and wetter see apple. The concentration of the Derris wash should be adjusted to 0.002 per cent. crystalline rotenone.

Modifications for Disease and Pest Intensity.

Winter washing does not in all seasons provide a control of Gooseberry Red Spider (*Bryobia ribis*). An infestation may be controlled by the application in April of 1 per cent. concentration of a white oil emulsion.

If Sawfly is absent, sprays 3a and 4 can be omitted. In some seasons it may be necessary to control a third brood by the application at the end of August of a Derris or lead arsenate wash. It should be noted that gooseberries are often infested by capsid when interplanted among apples.

The late application of a tar oil wash frequently checks bud damage by birds.

Modifications of Programme for Varieties.

Many dessert varieties, *e.g.* Yellow Rough, Early Golden Drop and Leveller are damaged by sulphur washes and dusts and should be sprayed with washing soda and soap (18 lb. soda and 10 lb. soap per 100 gall.) as a means of checking American Mildew.

VIII.—RASPBERRY.

	Stage.	Approximate date of spraying.	Materials per 100 gallons water.	Pests and Diseases Controlled.
1	Just before bud burst	From mid-March*	4-7½ gall. tar oil emulsion	Raspberry Moth
2	Full blossom	Early June	Derris or Lonchocarpus dust	Aphides Adults of Raspberry Beetle
3	2-3 weeks after petal-fall	Mid to end of June	Derris (see under) ½ lb. wetter or Derris dust	Larvae of Raspberry Beetle

* Also to the soil. See note on modification for pest intensity.

Specification of Materials.

For tar oil emulsion and wetter see apple; for Derris see plum.

The Derris or Lonchocarpus dust should contain not less than 0.18 per cent., and the wash not less than 0.004 per cent. crystalline rotenone. Many samples of Derris root contain 1.5 per cent. crystalline rotenone, and with a root of this concentration it is necessary to use 2½ lb. Derris root per 100 gallons wash. Lonchocarpus often contains 4-5 per cent. rotenone and it is only necessary to use 1 lb. of this material per 100 gallons. The application after petal fall is the more important, and a wash is preferable to a dust as it also provides a control of aphides.

Modifications for Pest and Disease Intensity.

If aphides are a pest in the bed and Raspberry Moth is absent it is advisable to spray in early February instead of mid-March with a tar oil emulsion. Frequently winter washing may be omitted.

Raspberry Moth may be checked by the very liberal application of a tar oil emulsion to the soil around the crowns and adjacent to the rows of raspberries just before bud-burst. Some damage to the plants may result but it is insignificant compared to the injury caused by the pest.

In some seasons Raspberry Beetle emerges early and causes appreciable flower-bud injuries, and when this occurs it is advisable to dust twice during the flowering period.

IX.—LOGANBERRY.

A programme similar to that for raspberry is recommended.

X.—BLACKBERRY.

A programme similar to that for raspberry is recommended. Blackberries are subject to aphid infestation and therefore a tar oil wash should be applied in each season, preferably in early February, but in mid-March if Raspberry Moth is present (see raspberry). Blackberries are sometimes an unsuspected centre of capsid bug infestations. These pests and aphides may be controlled by the application of D.N.O.C. petroleum washes (see apple).

Two applications of a Derris dust or wash should be applied after petal fall on account of the long flowering period, the first at the period recommended for raspberries and a second two weeks later. The wash is preferable to the dust, as it also provides a control of aphides.

XI.—STRAWBERRY.

	Stage and approximate date of spraying.	Materials per 100 gallons water.	Pests and Diseases Controlled.
1	Obvious crown development in March to early April	1½ gall. lime sulphur 1 lb. wetter 6 oz. nicotine	Strawberry Aphid Greenhouse Red Spider Mildew
2	Before flowering in mid-May	do.	do.
3	After picking of fruit or de-blossoming	do.	do.
4	Mid-July to mid-August	do.	do.

Specification of Materials.

For white oil emulsion see apple.

Alternative Spray Materials.

White oil emulsion at 1 per cent. concentration may be substituted for the lime sulphur and the wetter in spray 4. The oil emulsion provides a high control of Red Spider eggs. A combined wash of lime sulphur and oil emulsion is not recommended.

Supplementary Control Measures.

Strawberry beds should be established only from runners obtained from hot-water treated parents. The hot water treatment is the only method of ensuring a control of Tarsonemid Mite. The method consists of immersing runners for twenty minutes in hot water maintained at 110°F. It should

be noted that the temperature of the water must be uniformly maintained in the tank, as a momentary rise over 112°F. will cause considerable loss of plants.

Runners selected from hot water-treated parent plants should be dipped into either the lime sulphur-nicotine wash or nicotine-white oil emulsion (as recommended above) before planting out.

Burning off the dead leaves and straw in autumn is a valuable means of reducing Red Spider infestations.

Modifications for Pest and Disease Intensity.

The spray programme recommended above is intended as a routine procedure. In some circumstances nicotine-sulphur dusts may be substituted but with much less satisfactory results.

A METHOD OF SPRAYING OUTDOOR TOMATOES.

By H. G. H. KEARNS.

Outdoor tomatoes are subject to attack by Potato Blight (*Phytophora infestans*), more particularly in the West Country. The infection spreads rapidly during wet weather in late summer and in 1941 the loss from unsprayed crops in some localities was very severe. The fungus may be controlled by the thorough application of washes containing copper, such as the copper oxychlorides and cuprous oxide. A method of spraying the crop described below was tried on a commercial holding during 1941 and gave satisfactory results.

Experimental Procedure.

One and a half acres of tomatoes, including the varieties, Market King, Plumpton King, Radio and Potentate, were selected for the experiments. The crop was planted in double rows, with 12 inches between the rows and 18 inches between the plants, the double row units being separated by a distance of $2\frac{1}{2}$ feet. The plants were supported by strings and were sprayed when $2-2\frac{1}{2}$ feet high in early August.

A spray pump was placed at the headland so that the spray hose could be pulled between the rows for a distance of 75 feet. A crowbar or stake was driven securely into the ground in the middle of the row at the headland to fix the line of the hose down the row. This procedure permitted each sprayer to manage without assistance and avoided any undue damage to plants.

The crop was sprayed from the wide row spaces with a single or three nozzle adjustable gun, and it was possible to spray effectively to a distance of 20 feet. The distance sprayed on each side of a row depended on the velocity of the wind at the time of spraying. The use of an adjustable gun made it possible to obtain an even cover of the bottom and top leaves of near and distant plants.

A pump with an output of 7 gallons per minute at 350 lbs. per square inch pressure supplied either one three nozzle gun fitted with 5/64th discs or two single nozzle guns with 6/64th discs. It was necessary to apply 400 gallons of wash per acre to obtain a satisfactory cover. It was possible for two men to undertake all operations, moving pump, laying hoses, mixing and spraying wash, etc., and to apply with two single nozzle guns a total of 100 gallons per hour, provided water was readily available. Two men using the same pump but only one man spraying applied 70 gallons per hour.

Although only a single application of the wash (copper oxychloride) was made instead of the two or more normally recommended,* the control of blight was satisfactory. An adjacent unsprayed $1\frac{1}{2}$ acre of tomatoes suffered a nearly complete loss of crop. The high pressure and consequent buffeting of the foliage did not cause any damage to the foliage or fruit, nor was there undue deposit of wash on the fruit.

* Ogilvie, L., Diseases of Vegetables Bulletin, No. 123 (2nd edition), Ministry of Agriculture and Fisheries.

Suggested Lay-out of Tomatoes for Power Spraying.

The space between single or double rows of plants should be not less than 3 feet. The distance allows the hose to be drawn along without damage to plants, and in addition it permits of easier cultivation and harvesting, and of air circulation which retards the rate of spread of Potato Blight.

It is convenient to use a hose length of about 75 feet, and therefore the rows should be intersected by alleyways every 150 feet. The headlands and alleyways are not only useful for spraying purposes, but they are convenient for the harvesting of the crop. The width should be sufficient to allow of the easy movement of trolleys, etc. Along these alleyways overland steel water mains can be arranged with cocks at convenient intervals for watering the crop. These mains may also be used for conveying the copper washes, with the pump arranged at the end of the headland at a convenient point.

If this system of watering is not used it may be necessary to place the pump at points along the headlands and alleyways, and in this case provision must be made to supply the pump with water.

The sprayman should decide on the number of rows he can spray from his position between two rows, and every endeavour must be made to cover the foliage completely, more especially the lower leaves. The spray gun should be adjusted to a fine mist for spraying near rows and the adjustment gradually altered to reach the more distant rows.

Specification for Spray Equipment, etc.

A pump with a delivery of not less than 4 gallons per minute at 300—350 lb. per square inch is necessary for the satisfactory working of one single nozzle gun and multiples of this output, but not of the pressure, are required for each additional gun.

If steel mains are used any type of spray outfit will be suitable, provided the pump has the minimum capacity mentioned above. The outfit should be placed near a convenient water point. The cocks on the main should be fitted with $\frac{3}{4}$ " male B.S.P. thread or fitted with reducers to permit of the use of $\frac{3}{4}$ " female B.S.P. hose couplings. This dimension is becoming the standard size for spray hose connections.

If mains are not available and the outfit must be used at the headlands or in the alleyways, these latter must be of adequate width to permit of moving the pump, cisterns, hoses, etc., easily.

The wash should be agitated from time to time to prevent settling out of the fungicide. After spraying, the spray outfit, hoses, mains, etc., should be washed out with water.

A suitable small spray outfit mounted on a trolley complete with engine, pump, spray gun and hose will cost approximately £70.

A NOTE ON THE SO-CALLED DRY EYE ROT OF APPLES

ASSOCIATED WITH *BOTRYTIS CINEREA* PERS.

By E. H. WILKINSON.

During the past five years the writer has had under observation an unusual disease of apples for which the name Dry Eye Rot has been suggested (1, 5). Apples of the variety Laxton's Superb appear to be most susceptible, but comparatively severe infections have been observed also on the varieties Worcester Pearmain, Cox's Orange Pippin, Bramley's Seedling and John Standish.

Two reports on what appears to be the same disease have appeared in the literature. In 1940 (1) an eye-rot, attributed to *Botrytis cinerea*, was reported in New Zealand affecting fruits of the varieties Jonathan and Cox's Orange Pippin, and led to the rejection of the infected fruits for export because of the possibility of further rotting in transit. Affected apples held in cold storage for five months, however, showed no further developments of the trouble, and it was concluded that it would be safe to export fruits showing discolouration of the calyx. Wormald (5) has described, in 1940, a similar eye-rot of apples in England which he states appeared to be a result of infection by *B. cinerea*.

A large number of apples suffering from Dry Eye Rot were examined by the writer, and it was concluded that the development of the disease was the same on all varieties under observation. In its early stages it is not unlike the eye-rot caused by *Cylindrocarpum mali* (Allesch.) Wr. the conidial stage of *Nectria galligena* Bres. but differs in the later stages owing to its outstanding characteristic of arrested growth and its hard and dry texture.

Descriptions of Dry Eye Rot have been given (1, 5), but its development has apparently not been observed. In the summer of 1941 the initiation and subsequent development of the disease were studied by the writer. These may be divided into three stages.

Stage I. Towards the end of July a slight red colouration appears at the base of one or more calyx segments. The reddened area expands slowly in a radial manner, away from the calyx, leaving, in its wake, infected skin which is light brown in colour. The expansion is comparatively slow and has been observed continuing until the first week of September. By this time the lesions have diameters varying between $\frac{1}{2}$ —1". Internally the tissues, to a depth of $\frac{1}{10}$ " beneath the discoloured skin, are soft, watersoaked and light brown in colour.

Stage II. Having developed so far the lesions cease to grow and gradually dry out. These changes are accompanied by a gradual subsidence of the overlying skin which, at the same time, deepens in colour to dark brown or sometimes black. It also assumes a stretched parchment-like appearance and frequently becomes detached from the surrounding healthy skin at the periphery. Internally the watersoaked tissues have also dried out and become tough in texture.

The lesions at this stage are approximately circular and either surround

the calyx or, more frequently, are situated on one side of it. Their periphery is clearly defined and is surrounded by a thin band of red skin (Plate I, upper two apples).

Stage III. The lesions remain in the quiescent condition reached at the end of Stage II for a number of weeks. Subsequently during October and November the healthy skin immediately surrounding the lesions becomes light brown in colour and spreads until, after approximately 14 days, the whole apple is involved in a complete rot whose texture is spongy and soft to the touch, the typical Botrytis rot. Internally all the tissues are rotted, light brown in colour, watersoaked and emit an aromatic odour (Fig. 1, lower light brown in colour, watersoaked and emit an aromatic odour (Plate I, lower two apples).

The dried-out eye-rot as described under Stage II was found repeatedly during 1937-40 and isolations made from the thin layer of rotted tissues, and from spores appearing on the calyx segments and diseased skin, gave pure cultures of *Botrytis cinerea*. Although the results of these isolations were quite positive it was felt that the fungus was behaving in an unusual way by apparently ceasing to grow after producing a rot of small dimensions. It was thought that the original rotting was due to a physiological breakdown of the apple tissues around the calyx and followed by a secondary contamination by *B. cinerea*. In August 1941, however, the actual formation of the eye-rot was observed, as described in Stage I and isolations from the rotted tissues, which had been invaded by septate mycelium, yielded pure cultures of *B. cinerea*.

Spores and mycelium taken from cultures obtained from all stages of Dry Eye Rot were pricked into apples under laboratory conditions and produced typical Botrytis rots, but when the process was repeated, at the base of calyx segments of Laxton's Superb apples in late August, 1941, while on the tree, total rots or complete failure to take resulted.

Although *B. cinerea* has been isolated from all stages of Dry Eye Rot it is not possible to state definitely that it is the cause of the Dry Eye Rot phase, since identical symptoms have not been produced by artificial inoculations. Yet it is safe to say there is a close association between the disease and the fungus.

B. cinerea is the cause of a serious storage rot of apples popularly known as Grey Mould. Spores are carried into the store on the surface of apples and on germinating will penetrate injured fruits, reducing them to pulp-like rots in a comparatively short time. The fungus can then infect adjacent apples by spread of the mycelium from fruit to fruit. For example, in 1937, 37 apples of the variety Laxton's Superb were found cemented together by the mycelium of the fungus in one storage tray. It is possible that the damage was a result of an initial infection of one apple. Fruits suffering from stalk-end russet, e.g. Cox's Orange Pippin and Laxton's Superb, are very susceptible to attack (3).

Apples, suffering from Dry Eye Rot, provide an alternative method of conveying *B. cinerea* into apple stores. This was clearly demonstrated when a count of a sample of Laxton's Superb in September 1941 showed 178 fruits infected with Dry Eye Rot. On October 30th, 1941, 123, representing 69.1% of the infected fruits, had become totally rotted and in a few instances the

infection had spread to adjacent healthy apples. This is quite in contrast to the behaviour of apples stored in New Zealand which showed no such development after 5 months (1).

Dry Eye Rot appears to be most prevalent after a wet July or August, as has been also reported by Wormald, who suggests that the moistened calyx segments offered "a very suitable substratum for *Botrytis*, which then extended into the fruit itself." If the incidence of attack of *B. cinerea* is to be kept at a minimum, especially after a season which has favoured the development of Dry Eye Rot, it is most essential that fruits suffering from the disease should be discarded immediately.

It is difficult to describe why, in the case of Dry Eye Rot, there should be a temporary cessation in the progress of the lesion. Wormald (5) suggests the possibility of the formation of a protective barrier isolating the infected regions. The writer failed to observe any such layer after carefully sectioning many diseased apples. It is quite possible, however, that since the apples are in an active state of growth at the time of infection, they may isolate the lesion simply by a physiological process.

Two parallel cases in which an attack of *B. cinerea* is isolated to localised areas of infection are provided by the Chocolate Spot disease of broad and field beans and the *Botrytis* Rot of tomatoes. In the former, according to Wilson (4), two types of infection exist, (a) the "non-aggressive" form causing the typical chocolate spot symptoms, and (b) the "aggressive" form which causes blackening and death of part or whole of the shoot system. He found that the "aggressive" form could only be induced by the presence of optimum conditions of humidity, rain, temperature and wind and if one of these factors was lacking the "non-aggressive" form only would develop. In the case of *Botrytis* Rot of tomatoes, Read (2) observed lesions developing, "occasionally at the blossom end of the fruit if the large drop of water which sometimes collected there did not evaporate within twenty-four hours or so, but the rot caused in this manner frequently failed to spread through the entire fruit and the affected portions dried out."

Likewise, in the case of Dry Eye Rot of apples, it might be argued that under rainy, humid and warm weather conditions experienced in July the "aggressive" form of rot begins, but as soon as the meteorological conditions change to those less suitable for its development, *e.g.* dry, hot sunny days, the "non-aggressive" form is assumed and so the further spread of the fungus is checked. Similarly, when infected apples are placed in storage where the humidity is high, the fungus assumes a kinetic or "aggressive" form once more, advances into the healthy tissues and eventually involves the apples in a total rot.

Summary.

1. An account is given of the development of an apple disease called Dry Eye Rot, associated with the fungus *Botrytis cinerea* Pers.
2. Data are given which show that apple fruits affected with the disease and placed in storage may subsequently give rise to an epidemic of *Botrytis* rot.
3. The behaviour of the disease is compared with that of Chocolate Spot of beans and *Botrytis* Rot of tomatoes.

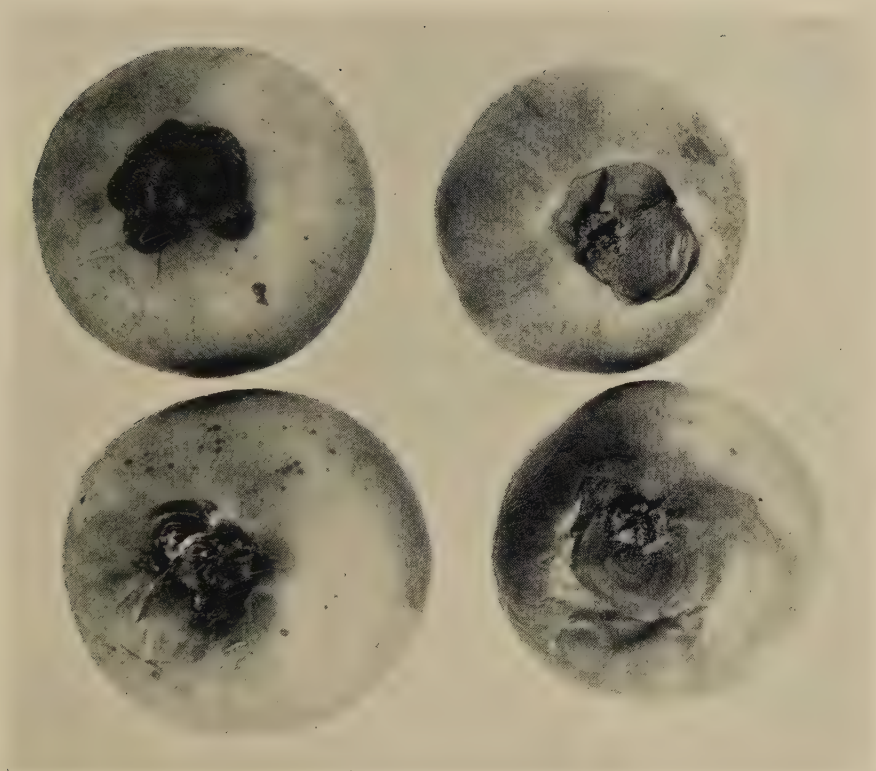


PLATE I.—Dry Eye Rot infecting apples of the variety Laxton's Superb.
(a) Upper two apples. Stage II (see text).
(b) Lower two apples. Stage III (see text).



4. It is suggested that changes in meteorological conditions are mainly responsible for the quiescent stage of Dry Eye Rot.

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OBSERVATIONS ON DOWNY MILDEW AND GREY MOULD ON GLASSHOUSE LETTUCES.

By L. OGILVIE and H. E. CROXALL.

During the winter of 1941-42 a large, heated greenhouse (100 × 40 ft.) and a small, cold lean-to greenhouse (80 × 30 ft.) at the Research Station were used for the production of a commercial lettuce crop, and the opportunity was taken of making continuous observations on the incidence of disease.

The varieties Cheshunt Early Giant, Cheshunt Early Ball, Gotte à forcer and Early French Frame (Blackpool strain) were sown in boxes of sterilised soil on September 16 and planted out in the houses in rows, approximately 9 in. between the plants and 9 in. between the rows, on October 21-24. There were two rows of each variety alternately (a total of 1,546 plants) in the large house and three rows of each variety alternately (a total of 752 plants) in the small lean-to house. The soil in the large house had been removed in the summer and replaced with maiden loam from a neighbouring hillside. That in the small house had carried lettuces in the previous year. In both cases the soil was watered rather heavily before planting.

Owing to a boiler difficulty very low minimum night temperatures, accompanied by high day temperatures, were experienced in the houses soon after planting. Thus on October 23 and 24 the minimum was 34° F. and the maximum 87° F. A series of low readings, going down to freezing point, were again experienced during the first four days of November. Subsequently, minimum temperatures of about 44° F. were experienced.

Downy Mildew (*Bremia Lactucae*).

Downy Mildew appeared on all the varieties in both houses soon after planting out. Counts were made of the diseased plants of the various varieties on December 12th, but no significant differences in susceptibility were observed. On November 5th more heat was applied in the large house, the temperatures rising to well over 65° F. during the day. At the same time the lower leaves were removed and the disease gave no further trouble. Although in the small house the temperatures remained low the plants had very largely "grown away" from the disease by mid-December, the lower affected leaves shrivelling up and the upper leaves, which did not touch the ground, remaining free from infection. No further watering was done in the cold house and there was no appreciable amount of Downy Mildew on any of the plants at the time of cutting in mid-February. Similar "growing away" of diseased plants was observed in cold commercial glasshouses elsewhere in the Province early in December. In tightly closed frames, however, the disease tended to persist on the lower leaves, hence it is advisable to remove these at intervals.

Although sporophores of the fungus were usually produced on the lower leaf surfaces, in bad attacks the lesions became water-soaked and in these cases the fungus sporulated on the upper surfaces also. Such leaves often became invaded secondarily by *Botrytis*.

In the cold house blocks of plants were dusted with each of the following substances: hydrated lime, finely divided sulphur, a cuprous oxide dust and

a 20% Bordeaux dust. None of these substances gave evidence of any marked capacity to control Downy Mildew, but it was difficult to cover the lower surfaces of the leaves.

In another commercial house in Somerset badly affected seedlings were dipped, before planting out, on November 10th, in colloidal copper and sulphur preparations, with and without ester salts and sulphonated lorol respectively as spreaders. Three weeks after treatment all the plants, including the untreated plants, were growing away from the disease satisfactorily. None of the substances injured the plants and there appeared to be some slight control following dipping in ester salts.

Grey Mould (*Botrytis cinerea*)

Grey Mould became common in the large house at an early date and counts were made of diseased plants at frequent intervals. The fungus attacked the plants in the usual way, *i.e.* the lower leaves were first affected and the disease passed thence into the stem, causing a wilt. The early prevalence of the trouble was attributed mainly to considerable differences between day and night temperatures, resulting in accumulation of moisture under the lower leaves, and to foggy weather which made ventilation difficult. Counts of diseased plants on seven different dates appeared to confirm the first theory.

One section of the large house, comprising about 400 plants, was kept quite dry throughout the growing period. This had 66 *Botrytis* plants during the period under observation, whereas the neighbouring block which was watered when the plants seemed to require watering had 92. Other watered blocks had 85 and 79 *Botrytis* plants respectively. This result, which appears to be at variance with the general opinion which holds that wilting of the lower leaves leads to infection, was probably due to failure of the water to penetrate into the soil. Later examination of the soil showed that beneath the surface the soil was still dry so that the water had probably only wet the soil surface. This would make the atmosphere round the plants moist and still more favourable to the development of *Botrytis*.

The numbers of diseased plants of the four varieties were also counted. It was found that of the 1,536 plants in the large heated house the following numbers of plants were infected: Gotte à forcer 98, Cheshunt Early Giant 88, Cheshunt Early Ball 78, and Early French Frame (Blackpool Strain) 40. This bears out the prevalent opinion that the last-named does not take the disease so badly as the Cheshunt strains. In the cool house, however, all the varieties were almost equally affected.

It was noticed that the disease appeared to spread from diseased plants to neighbouring healthy ones and in the cold house to be concentrated in damp spots caused by drips from the roof. The plants in the warm house received an overhead watering late in January, and although this brought about a striking improvement in the appearance of the lettuces and hastened their hearting it was followed by an alarming spread of *Botrytis* rot of the heart leaves.

In both houses Cheshunt Early Giant gave the best results. Hearting was quite good. Cheshunt Early Ball did not heart quite so well and was paler in colour. Early French Frame (Blackpool strain) grew well but hearted poorly under local conditions, while Gotte à forcer produced compact hearts

at a late date. The diameters of the mature plants were 8, 7, 6 and 6 in. respectively.

The Gotte à forcer plants became infected at an early stage with a rotting of the margins of the central leaves, which appeared to spread to the other varieties. The disease is at present under investigation. Gotte à forcer was severely infected, the majority of the plants being useless for market, while the other varieties were little damaged.

SIMPLIFIED METHODS OF POTATO BLIGHT CONTROL. PROGRESS REPORT III.

By R. W. MARSH and H. MARTIN.

The experiments recorded below form a continuation of those carried out in 1940 and described in the previous Annual Report (pp. 63-79). In 1941, however, no dusting trials were attempted.

Experimental.

Materials and Methods.

Three well-known proprietary brands of dispersible copper fungicides, Coppesan, Perenox and Soltosan, were included in the trials, together with Bordeaux mixture. Descriptions of these materials were given in Progress Report I. As in 1940, the two modes of application employed for the proprietary fungicides were (1) spraying with a "Solo" bucket pump and (2) sprinkling from a watering can fitted with a fine rose. Bordeaux mixture, in 1941, was applied only by the spraying method. All the fungicides were used throughout at strengths equivalent to 0.25% Cu.

Plots.

(1) *At Long Ashton: variety, Majestic.* This trial comprised 28 plots (each 5 rows $\times$ 30ft.), forming four blocks within each of which the following seven treatments were randomised:—

- | | |
|-----------------------|------------------------|
| A: Perenox sprinkled. | D: Soltosan sprinkled. |
| B: Soltosan sprayed. | E: Coppesan sprayed. |
| C: Bordeaux sprayed. | F: Coppesan sprinkled. |
| G: Perenox sprayed. | |

(2) *At Blaise: variety, Arran Banner.* At this centre the potatoes formed a narrow strip, so it was necessary to use plots 4 rows $\times$ 30ft. The strip was divided transversely into four blocks with four randomised treatments in each, namely:—

- | | |
|----------------------|------------------------|
| A: Perenox sprayed. | C: Soltosan sprinkled. |
| B: Soltosan sprayed. | D: Perenox sprinkled. |

(3) *At Dundridge Farm, Hanham: variety, Majestic.* The layout of this trial included 16 plots (each 5 rows $\times$ 30ft.), forming four blocks with the following four randomised treatments per block:—

- | | |
|-----------------------|------------------------|
| A: Perenox sprinkled. | C: Coppesan sprayed. |
| B: Perenox sprayed. | D: Coppesan sprinkled. |

Spray Applications.

	First Spraying.	Second Spraying.
Long Ashton	July 30	—
Blaise	August 6	September 11
Dundridge	July 23	September 3

Each plot at Blaise required approximately two gallons of spray fluid per application. Elsewhere the quantity used per plot, either for sprinkling or spraying, was $2\frac{1}{2}$ gallons or a little less.

Weather.

Between July 11 and July 19, two inches of rain fell. A fine week followed, and the last week of the month was again showery. August was outstanding as a month of persistent rain, a total of 4.84 in. being distributed over 23 days. September, on the other hand, was remarkably dry and sunny, the total rainfall for the month being only 0.5 in.

The spraying at Long Ashton on July 30 was carried out in somewhat unfavourable weather, with light showers falling soon after the application. All other spray applications were made in good weather, but the succession of wet days in August caused a deferment of the second applications until early September, when blight had already appeared.

Blight Control.

Blight was first noted on the Dundridge plots on September 2, when 2-3 blighted leaflets per plot were present. In the same week it also first appeared at Long Ashton and at Blaise. The disease spread very rapidly at Long Ashton and at Dundridge, but more slowly at Blaise: a record of the blight estimates made is given below.

The assessment of the prevalence of blight was made on the basis of numerical estimation ranging from 0 (= no blight lesions seen) to 10 (= complete defoliation of the haulm), a method described by Marsh, Martin and Munson (1937). The differences in the rate of spread and degree of attack by blight in differently treated plots were so small that it is unnecessary to give the full figures, but a summary is assembled in Table I, from which it will be seen that spraying and sprinkling are equally efficient in retarding the spread of the disease. The differences in blight control between different materials in the Long Ashton trial are to be attributed to the unfavourable weather at the first application, for at other centres the three proprietary products proved equally effective. The figures are recorded solely for comparison with the copper retention figures.

TABLE I.
MEAN ESTIMATES OF BLIGHT INFECTION.

(a) SPRINKLED *v.* SPRAYED.

Trial at					Sprinkled Plots.	Sprayed Plots.	Unsprayed.
Long Ashton :							
8/9/41	..	..	..	..	2.75	2.83	9.00
15/9/41	..	..	..	..	7.42	7.42	9.00
Blaise :							
9/9/41	..	..	..	..	1.00	1.00	7.00
12/9/41	..	..	..	..	2.50	2.50	8.00
22/9/41	..	..	..	..	3.00	3.12	9.00
Dundridge :							
4/9/41	..	..	..	..	1.25	1.75	—
13/9/41	..	..	..	..	2.62	2.75	5.00
22/9/41	..	..	..	..	4.25	4.12	7.00

(b) MATERIALS.

Trial at		Bordeaux.	Coppesan.	Perenox.	Soltosan.
Long Ashton :*					
8/9/41	..	2.50	2.87	2.62	3.12
15/9/41	..	6.50	7.50	6.87	7.87
Blaise :					
9/9/41	..	—	—	1.50	2.50
12/9/41	..	—	—	4.25	4.75
22/9/41	..	—	—	6.25	6.00
Dundridge :					
4/9/41	..	—	1.50	1.50	—
13/9/41	..	—	2.37	3.00	—
22/9/41	..	—	3.75	4.62	—

*On the transformed scale $(x + \frac{1}{2})^{\frac{1}{2}}$, the Long Ashton figures yield the following means: 8/9/41: Bordeaux, 1.715; Coppesan, 1.815; Perenox, 1.742; Soltosan, 1.879; with significant differences ($r=0.05$) between the three proprietaries of 0.243 and between Bordeaux and any proprietary 0.298. The corresponding figures of the count on 15/9/41 were: Bordeaux, 2.645; Coppesan, 2.806; Perenox, 2.712; Soltosan, 2.892 with S.D.s of 0.124 and 0.152 respectively.

Spray Retention.

As in the 1940 trials foliage samples were collected periodically for the determination of the amount of copper retained on the haulm throughout the period of possible infection. The estimates, made by the method described by Marsh, Martin and Munson (1937), are expressed in Table II as units representing one-tenth milligram of copper per 50 leaf discs of diameter 1.4 cm.

TABLE II.
MEAN ESTIMATES OF COPPER RETENTION.
(a) SPRINKLED *v.* SPRAYED.

Trial at			Sprinkled.	Sprayed.	S.D. (P=0.05)
Long Ashton :					
Leaves sampled	1/8	.. ..	4.66	4.90	0.535 (Showers)
Blaise :					
Leaves sampled	8/8	.. ..	13.31	8.30	1.319
Leaves sampled	12/9	.. ..	13.13	12.88	1.918
Dundridge :					
Leaves sampled	24/7	.. ..	16.20	13.13	1.102
Leaves sampled	4/9	.. ..	11.99	7.69	1.420

(b) MATERIALS.

Trial at			Coppesan.	Perenox.	Soltosan.	S.D. (P=0.05).
Long Ashton :						
1/8	.. ..		3.35	7.64	2.99	0.677
Blaise :						
8/8	.. ..		—	13.80	7.81	1.319
12/9	.. ..		—	15.06	10.25	1.918
Dundridge :						
24/7	.. ..		13.27	16.07	—	1.102
4/9	.. ..		9.97	9.71	—	1.420

In contradistinction to the previous year's results, more of the spray has been retained on the sprinkled than on the sprayed leaves even at the first application, though no difference in degree of blight control was observed. The sprinkling method does not therefore appear to be more wasteful of spray even before the full development of the haulm. The comparison of retention between the three proprietary products in the Long Ashton trial is, as pointed out above, impossible as the figures are merely a measure of the degree to which showers had washed off the undried spray. But the parallelism between retention and blight prevention is interesting in its suggestion that the retention figures are low enough to permit differences in fungicidal efficiency, under the particular conditions, to be revealed. In the Blaise and Dundridge trials, however, the level of the retention figures throughout is sufficiently high to ensure blight control, although differences exist which can be correlated with the speed of settling of the respective suspensions and indicate that the stability of the suspension is a factor not to be neglected in the specification of dispersible powders intended for spray use.

Phytocidal Effects.

At Dundridge and at Long Ashton no phytocidal effects were noted, but at Blaise, where the plants were less vigorous and of a different variety, a yellowing of the leaves accompanied by a diffuse fine spotting, appeared from mid-September onwards. Eye estimates showed that these symptoms were most pronounced on the plots that had been treated with Perenox. The effect did not appear until the leaves were nearing their normal period of dying off, and it is most unlikely that any adverse influence on cropping resulted.

Summary.

1. A continuation of the tests of simplified methods of potato blight control, suitable for allotments and private gardens, has shown that sprinkling from a watering can is as efficient as spraying in retarding the spread of blight.
2. The three proprietary fungicides employed in the 1941 trials proved equally satisfactory.

Acknowledgments.

The trials at Blaise and at Dundridge Farm were made by permission of the Bristol Corporation Parks Committee. The writers express their thanks to Mr. J. P. Inglis (Parks Superintendent) and to Park Rangers Watkins and Chapman for facilities and assistance. They are also indebted to Mr. R. F. Batt, who carried out the copper determinations.

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THE FUNGICIDAL ACTION OF COPPER AND SULPHUR.

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Introduction.

Experiments have been in progress for the last year having as their object the application of certain statistical methods to the identification of the chemical state in which fungal spores absorb toxic substances used as fungicides, with a view to the application of the results to improvements in fungicidal methods.

The statistical method used, referred to as the theory of variability, is based on the principle that the individuals composing a population of fungus spores will differ from one another the more in their tolerance to a given fungicide, the more factors peculiar to each spore operate in the process of absorption. In an attempt to find a suitable statistic for measuring this effect quantitatively, it was found that the parameter called "Variability" not only served this purpose, but was affected in a predictable way by the state of association or dissociation in which the toxic molecules operated, and also had other useful mathematical properties. Variability is defined as the variance of x^a divided by $a^2(\overline{xa})^2$ where x is the tolerance of an individual spore, and a is a quantity called the "index of variation," characteristic of the type of fungicide and species of fungus used; it is defined by the condition that x^a be normally distributed in the population. Briefly it is found that, in compounds whose toxic action is due to a given element or radicle, those compounds which can be absorbed by the spore will give a lower variability than non-absorbable compounds having the same number of atoms of the toxic element, or radicles; again, the variability to any compound containing m atoms of the toxic element per molecule will bear to one having n such atoms, the ratio of m^2/n^2 , while the ratio of the indices of variation will be n/m , provided that one of the two exists in a trace only, in equilibrium with the other in aqueous solution. Similar relations hold for toxic molecules which undergo electrolytic dissociation.

These relations were derived from statistical theory and the laws of chemical equilibrium; the experiments which have since been made have confirmed them quantitatively within the limits set by statistical errors, particularly in the case of sulphur, the oxyacids of which element offer an excellent field for the purpose. The arithmetical procedure for estimating variability is quite simple, and an approximate method for the estimation of the index of variation has been devised; a full account of the theoretical work referred to, as well as of the experiments on sulphur, is at present in the press for the *Annals of Applied Biology* (vol. 29). The experiments on copper are described in *Ann. Appl. Biol.* 28, p. 389.

The Mode of Action of Copper.

In the experiments on copper, a number of different complex cupric compounds, copper sulphate, and certain complexes of univalent copper with thiourea were tested in solution, while Bordeaux mixture, cuprous oxide, and monothiourecuprous chloride were investigated as aqueous sprays. The

method in each case consisted in germinating the conidia of *Macrosporium sarcinaeforme*, or *Botrytis allii*, in a series of solutions of the compound under test, or in distilled water on the surface of prepared slides sprayed with a suspension of it. By the counting of from 200 to 1,000 spores, the percentage germination in each concentration used could be estimated, and from the results estimates were made of the variability, as well as of the mean tolerance (i.e. the LD50). Usually it was aimed to have about 5 to 7 concentrations of the fungicide between those causing 0% and 100% killing of the spores.

The cupric complexes tested (malonate, glycinate, alaninate, and d-valinate) showed in general a greater variability in the spores than copper sulphate, though there was not a significant difference with the last-named. On the other hand, salts of various thioureocuprous ions were found to evoke a uniformly smaller variability than copper sulphate; the compounds used were $\text{Cu}(\text{SC}(\text{NH}_2)_2)_3 \cdot \text{Cl}$, $\text{Cu}_2(\text{SC}(\text{NH}_2)_2)_5 \cdot \text{SO}_4 \cdot 2\text{H}_2\text{O}$ and $\text{Cu}(\text{SC}(\text{NH}_2)_2) \cdot \text{Cl}$.

From these results it may be inferred that the spores are incapable of absorbing the complexes (with the possible exception of the valinate), which must, as a first stage, be broken down to simple Cu^{++} ions. But, since the thiourea complexes give a lower variability, it is clear that the simple Cu^{++} ion is not itself the form in which the element is absorbed; there exist other complexes capable of being absorbed, of which the thiourea compounds are evidently one group, and so presumably the spores, by means of some compound present in the spore secretion, bring the copper into a new complex form before it can pass through the spore walls. There is no evidence that thiourea itself is present in the spore secretion. It is interesting to note that according to the results of Horsfall, Marsh and Martin*, the amino acid complexes of copper were more toxic than copper sulphate, though from their figures it is not possible to compute the variabilities. It may be that a difference exists between different molecules and ions formed in solutions of such compounds, and that their relative proportions may have differed under different conditions of experiment.

Of the insoluble compounds tested, Bordeaux mixture acted in essentially the same way towards the spores as did copper sulphate, while cuprous oxides (both red and yellow) differed only in being one half as toxic for a given quantity of copper. The two species of fungi tested gave the same results throughout, although cases have since been observed in which they behave differently, for example, towards alkyl-mercury compounds.

The Mode of Action of Sulphur.

In the experiments on this element, hydrogen sulphide (in gaseous form), sulphur (as a spray in water), and various sulphur oxyacids (as solutions of their sodium salts, approximately neutral in reaction) were tested on the spores of *Macrosporium sarcinaeforme*.

The index of variation of the spores to copper compounds had always been zero (this is equivalent to saying that the logarithm of the tolerance was normally distributed in the spore population), but with sulphur it was found that the index was not zero, and therefore varied with the number of sulphur atoms in the molecule in the manner predicted by the theory. The index was rather less than unity with hydrogen sulphide and sodium hydrogen sulphite,

* Ann. Appl. Biol. 24. 867 (1937).

about $\frac{1}{2}$ with sodium dithionite, and $\frac{1}{4}$ with sodium tetrathionate. The index in the case of sulphur was $.38 \pm .22$. The sulphate, thiosulphate, and dithionate were found to be non-toxic. The variabilities were found to increase in the order $\text{H}_2\text{S} \cdot \text{Na}_2\text{S}_2\text{O}_4 \cdot \text{S}_2 \cdot \text{Na}_2\text{S}_4\text{O}_6$; that to NaHSO_3 (acid solution) came between the first two, but was significantly different from neither; this compound in alkaline solution gave a significantly higher variability.

From the non-toxicity of thiosulphate, which was maintained even at a pH sufficiently acid to cause a temporary deposition of sulphur, it was concluded that the HS^- ion could not be absorbed by the spores and that whatever the ion might be that was effective, it must be one having two atoms of sulphur to the molecule. Of these, HS_2^- is present in solutions of hydrogen sulphide exposed to the air, and $\text{S}_2\text{O}_4^{--}$ is of course the principal ion present in solutions of dithionites: according to present theories of the hydrolysis of sulphur, pyrosulphoxylate ($\text{S}_2\text{O}_3^{--}$), an isomer of thiosulphate, is present in the hydrolysate, and it may be that this compound is absorbed; but since the variability towards sulphur is higher than that to dithionite, and since thiosulphate is non-toxic, it is unlikely that this compound is effective. It was concluded from arguments such as these that either (a) both hydrodisulphide and dithionite (and possibly the very unstable thiosulphite) are able to penetrate the spores, or (b) the only permeative compound is the thiosulphite, and that hydrodisulphide is oxidised, and dithionite reduced, to this form in the zone immediately adjacent to each spore, where the spore secretion can act most readily. In the toxic action of sulphur pyrosulphoxylate is considered to be an intermediary, but it must be pointed out that *Macrosporium* is not a particularly sulphur-sensitive fungus. The toxicity of sulphite is due, in this theory, to the small concentration of pyrosulphite present in equilibrium.

It would be instructive to compare *Macrosporium* with some more sulphur-sensitive species by the aid of this theory; it seems possible that there may be a connection between the tolerance of this species to sulphur and its resistance towards molecules containing one atom of sulphur.

THE LARGE-SCALE PRESERVATION OF PLUMS BY THE SULPHUR DIOXIDE COLD PROCESS.

By VERNON L. S. CHARLEY, D. P. HOPKINS, M. E. KIESER and V. E. SILLS.

The cold process for preserving fruit with SO_2 was first described by B. T. P. Barker and O. Grove, in the Annual Report of this Station for 1924 (p. 97). In 1934 a further paper on the method by V. L. S. Charley appeared in the Annual Report (p. 255), this later contribution being mainly concerned with the removal of SO_2 by normal jam-making processes after preservation. In both papers the hot process, in which the fruit is cooked and pulped prior to the addition of SO_2 , was also given attention and compared from various angles with the cold process.

In these researches it was found that the cold process compared satisfactorily with the hot pulp method. The jam industry, however, has always taken the view that the cold process is greatly inferior. The two principal objections raised against the cold process seem to be firstly, that there is a much greater loss of pectin during the storage of the preserved fruit, and secondly, that the cold process requires greater storage capacity per ton of fruit.

In normal times it would be immaterial which method was preferred by the jam makers, but in wartime the wastage of any proportion of a large fruit crop is clearly undesirable, and in the event of a glut crop of plums it is felt that the cold process could preserve a much greater proportion of the crop *in the available time* than the hot process. The time factor should be emphasised in this connection. A "breakdown" plum crop involves the harvesting of a very high tonnage of fruit from a few areas of intensive cultivation, and the fruit can only be kept without softening and rotting for a few days. The hot process involves transporting the fruit to factories where steam-pans are available, whereas the cold process can be operated almost anywhere since it requires nothing more than the advance preparation of suitable storage space and supplies of SO_2 solution. Preservation by the cold process could indeed be largely done in the plum orchards themselves, although the service of coopers would be essential for tightening the casks. It is claimed, therefore, that in the short period of the plum crop the cold process would preserve a greater tonnage of fruit than the hot process. Unfortunately the long-established prejudice of the jam industry against this method has discouraged its use; but, in view of the present wartime shortage of fruit for jam-making, a further attempt to overcome these criticisms was undertaken. The opportunity of preserving a greater proportion of a heavy plum crop, should one occur in 1942 or 1943, would seem to be a matter of primary importance to the wartime jam industry and in the national interest.

Owing to the need for economy in space many details that have been published in the 1924 and 1934 Long Ashton Reports have not been repeated. Also a more detailed account of the present work will be published elsewhere

at a later date. The present communication should be regarded as a condensed statement of the problem and its examination.

The following main points have been investigated :

- (a) Pectin retention in hot and cold processes.
- (b) Effect of varying strengths of SO_2 on the efficiency of the cold process.
- (c) Effect of variety and maturity of plums on cold process results.
- (d) Distribution and changes of strength of SO_2 in fruit during preservation.
- (e) Effectiveness of various lining materials that could be used in storage vessels for large-scale cold process preservation.

The process has been examined solely in regard to plums since the question of large surpluses of other soft fruit does not seem to arise as a wartime problem.

It will be shown that, from the wartime angle as outlined above, the cold process merits the fullest re-consideration by the jam industry.

A. Pectin Retention in the Hot and Cold Processes.

In the Long Ashton Report of 1924 Barker and Grove noted a loss of pectin strength in both processes during storage ; but this was not established to be any greater in either process, and they concluded that the pectin loss was possibly a phenomenon involving more complex factors than a simple contrast between methods of preparing fruit for SO_2 treatment. The recent experience of some research and technical workers elsewhere, however, has been that the loss is much greater with the cold method.

Direct comparative tests were therefore carried out. Two varieties of plums were used, Victoria and Purple Pershore, in sound commercial condition. Quantities of the same batch of fruit of each variety were preserved on the same day by both methods. In the cold process the fruit was covered with an aqueous solution of 1,000 parts per million SO_2 and the cask sealed. The hot processed fruit was pulped according to standard practice, involving the addition of a greater proportional amount of SO_2 . A fair comparison of the two processes would not have been obtained if the usual SO_2 strength for either process had been modified to equal that of the other.

The preservation was done in August, 1940, during the heavy crop of that year. The fruit was left until June 1941, when a large number of tests and analyses were performed.

(i) *Calcium pectate estimations.*

It is not suggested that calcium pectate estimations are true indications of the setting-values of pectin material. Rather they are regarded as chemical assays of the amounts of pectin-type material present, some of which may or may not be capable of functioning in the production of a gel. The figures do show, however, that there is more pectin-type material retained by the hot processed plums. The analyses refer to the calcium pectate figures for the whole pulp, and to the preserved plums removed from the SO_2 liquor after the storage period.

TABLE I.

CALCIUM PECTATE DATA FOR HOT AND COLD PROCESSED PLUMS.

	As % Fruit and Pulp.	
	Total.	Soluble.
Victoria, Cold	0.651	0.158
Victoria, Hot	0.810	0.826
P. Pershore, Cold	0.535	0.092
P. Pershore, Hot	0.662	—

(ii) *Physical Tests of Pectin Strength.*

Extractions of the pectin were made by boiling the preserved materials with water under identical conditions, except that in the case of the cold processed fruit the volume of the liquor equivalent to the weight of the fruit taken was used as part of the amount of extracting liquid. There is, of course, no surrounding liquor to be considered in the case of the pulped fruit. The soluble solids content of each extract was determined and from this figure was calculated the weight of sugar required to be added so that, when the extract was boiled to a fixed final weight, the final soluble solids content would be 70%. All boiling was done on the same hot-plate for each extract, and the pH values of the extracts were measured but found to be so close that this factor in gel-formation could be regarded as a non-variable.

The gels formed were left to cool for 24 hours and then tested for strength in a B.A.R. jelly-tester. The figures given here are comparative figures only, and cannot be regarded as actual measures of rigidity in mechanical units.

Variety.	Process.	Jelly-Strength.
Victoria	Cold	3
Victoria	Hot	22
Purple Pershore	Cold	9
Purple Pershore	Hot	43

The results of these tests refer to the gel formed from a strained extract of the plums and contrast strongly from the jam tests which follow.

(iii) *Jam Tests.*

Comparable stoneless jams were then made. In the case of the pulp, 4 lb. of pulp and $3\frac{1}{2}$ lb. of sugar were boiled to 68/69% soluble solids, determined by a refractometer. To obtain a comparable fruit standard with the cold processed fruit it was necessary to take into account the dissolved plum constituents in the liquor; and calculating from the soluble solids content of the liquor it was found that 3 lb. $13\frac{1}{2}$ oz. of whole fruit plus the equivalent proportion of liquor (2 lb. 8 oz. containing $2\frac{1}{2}$ oz. of dissolved solids) should

be taken. This, of course, necessitated more boiling than in the case of the pulp. The cold processed fruit and liquor was boiled to approximately the same consistency as the pulp before the $3\frac{1}{2}$ lb. of sugar was added. This greater amount of boiling may have been disadvantageous to the pectin strength, but it is in any case an inherent part of a practical comparison of the two processes, though the question whether all the liquor need be used in making jam from cold processed fruit is a point that is dealt with later.

The four jams all set well. They were examined a month after making and, while the hot processed plums had given the firmer set, that from the cold processed fruit was quite firm enough to meet all commercial requirements including that of ability to travel. At the time of writing this communication, six months later, the jams have been re-examined, and far from any deterioration having taken place, the sets of all have become slightly more rigid.

In flavour and colour there was nothing to choose between the two jams from each variety; and no toughening of skins was noticeable, a point that has been made in the past against the cold process.

Conclusion from Pectin Tests.

Both the chemical and physical determinations for pectin have shown that there is a greater loss of pectin value in the cold process than in the hot. But jam-making tests have shown that this loss is not so great as to prevent the manufacture of satisfactory jams, probably because of the large initial pectin content of plums. With fruits less rich in pectin similar losses due to the cold process might well be a grave disadvantage; but there would seem to be no need to add pectin in order to make satisfactory jams from cold-processed plums.

A point which is worth noting is that the cold process in these tests showed greater efficiency in preservation. The hot-processed pulp from Victoria plums, despite the higher SO_2 content, showed signs of slight fermentation, a yeasty smell being given off when the pulp was boiled; this did not persist in the final products made, but it should be pointed out that in the many samples of plums put down by the cold process in these experiments there was not one case of even slight fermentation within twelve months.

B. Varying SO_2 Strengths in the Cold Process.

The full data obtained in this investigation will be given elsewhere later. Here only a shortened version of a test with Purple Pershore plums is given as an indication of the results obtained.

Batches of the same pick were preserved in SO_2 solutions varying from 800 to 2,000 parts per million strength. Only the results from the two extreme strengths will be considered here. After six months the dissolved solids in the liquors were practically the same in both cases. The calcium pectate figures showed slightly better retention of pectin-type material with the stronger SO_2 treatment, but the strength of gels made under identical conditions was the same in both cases. Jams made from both lots revealed no differences, the residual SO_2 being low in both cases and only slightly greater in the experiment with the 2,000 p.p.m. of SO_2 .

There would seem to be no real advantage, therefore, in using SO_2 solutions as strong as 2,000 p.p.m. Perfect preservation was given by the

800 p.p.m. solution but in general practice the use of 1,000–1,300 p.p.m. is recommended as giving a sufficient margin of safety with reasonably sound storage vessels.

C. Effect of Maturity of Plums on the Cold Process.

A typical test of the maturity effect with Purple Pershore plums is summarised here. Immature, mature, and over-ripe fruit was processed cold with 1,000 p.p.m. SO_2 solution. After six months the fruit was all perfectly sound in condition except that the over-ripe sample contained much broken fruit, which was to be expected in view of its soft condition before preservation. There were no marked variations found in any analyses of the liquor or whole fruit, and satisfactory jams were made from each sample. Tests of jelly strengths showed slight differences, the strengths of the immature, mature, and over-ripe fruit being respectively 9, 5, and 4 (comparative figures). This variation might well have been found in jelly-strength tests on the fruit before preservation but unfortunately there was not time in the short plum season to carry out on fresh samples the same number and variety of tests that could later be undertaken with preserved fruit.

Other maturity tests have revealed that this is not a variable that effects the cold process in any marked manner. From the point of view of obtaining whole fruit in liquor that is free from suspended matter—a factor that perhaps does not matter to the jam-maker—it is clearly best to preserve plums before an over-ripe stage has been reached. Nevertheless, where this cannot be avoided, the SO_2 solution at 1,000 p.p.m. strength will immediately prevent further deterioration in the fruit.

In this connection it should be pointed out that jams made from immature plums after preservation were superior in flavour to the control jams made from the same batches of immature plums before preservation. In the jams from the sulphited plums the high acidity that had been found in jams from fresh fruit was not apparent. This clearly defined flavour difference, which was noticed by each of several tasting panels, was entirely unexpected.

As an explanation it can be surmised that in the case of immature fruit the SO_2 penetration through the hard skin is slow and consequently the interior of the fruit continues to ripen for a short time after immersion. Acceptance of such a theory does not conflict with the view just expressed that over-ripe fruit is immediately preserved by the SO_2 : for in this case the skins of the fruit will be very soft and frequently split so that there would be no time-lag in SO_2 penetration.

This theory can be extended to provide a possible explanation for the differences in pectin retention for the hot and cold processes. It is well known that the ripening of fruit is associated with a decline in pectin strength. In the hot process the SO_2 can instantly penetrate an enormously exposed surface of plum tissue, there being no skin seal to penetrate. All continuation of ripening must therefore be considered to cease with the admixture of the SO_2 . But in the cold process except with over-ripe fruit, which will in any case have lost some of its pectin strength through its condition—the time-lag before penetration may allow further ripening and therefore a loss of pectin.

It should be pointed out that this theory is purely speculative, and further work is needed to prove or disprove it. As will be shown below, however, in the section on distribution, a definite lag in SO_2 penetration of the fruit does occur.

D. Effect of Variety on the Cold Process.

Numerous tests carried out at Long Ashton in 1940 involved the cold process preservation of Purple Pershore, Yellow Egg, Victoria, Czar and Monarch varieties of plums. Nothing was noted to indicate any varietal difference in the efficiency of preservation. In the next section the data relating to the distribution of SO_2 serves also to illustrate the similarity of figures for different varieties.

E. Distribution of SO_2 During Preservation.

A number of small batches of plums was preserved by the cold method in well-sealed glass bottles; for each treatment several identical bottles were stored, and at varying periods afterwards single bottles were opened and SO_2 determinations (by the Monier-Williams' method) made on the liquor, flesh, skins, and stones. The figures for the skins and stones are slightly uncertain; with the skins there is apt to be some loss of SO_2 to the atmosphere during the operation of dissection; with the stones, it was found that the SO_2 content was liable to vary from stone to stone in the same batch suggesting individual variations in the nature of the stones which affected their capacity to take up SO_2 . The figures given for the liquor and the flesh of the plums, however, can be regarded as subject to no error outside normal experimental limits.

TABLE II.
DISTRIBUTION OF SO_2 IN VARIOUS TISSUES OF PLUMS DURING PRESERVATION.

	1,000 p.p.m.				2,000 p.p.m.			
	Stones.	Liquid.	Skins.	Flesh.	Stones.	Liquid.	Skins.	Flesh.
	(after 2 days).				(after 3 days).			
First Determination ..	0	515	268	256	648	839	596	619
After 11 days ..	113	460	386	353	1970	763	589	670
After 30 days ..	1001	369	330	323	1499	660	535	567
After 3 months ..	842	335	252	274	1494	744	564	574
After 6½ months ..	995	306	272	283	1278	667	529	560
After 15 months ..	1079	265	223	247	1663	550	392	463

TABLE III.
DISTRIBUTION OF SO_2 IN VARIOUS TISSUES OF YELLOW EGG PLUMS DURING PRESERVATION.

	1,000 p.p.m.				2,000 p.p.m.			
	Stones.	Liquid.	Skins.	Flesh.	Stones.	Liquid.	Skins.	Flesh.
After 4 days ..	97	542	284	262	322	960	532	652
After 11 days ..	916	514	383	354	1982	906	601	671
After 31 days ..	1178	515	323	294	1714	688	451	563
After 4 months ..	1194	440	427	370	—	—	—	—
After 6 months ..	1071	394	246	356	1570	723	464	572
After 14 months ..	1092	222	226	182	2083	765	563	598

TABLE IV.

DISTRIBUTION OF SO_2 IN VARIOUS TISSUES OF MONARCH PLUMS DURING PRESERVATION.

	1,000 p.p.m.				2,000 p.p.m.			
	Stones.	Liquid.	Skins.	Flesh.	Stones.	Liquid.	Skins.	Flesh.
After 1 day ..	0	863	262	271	625	1330	676	643
After 7 days ..	296	638	505	427	649	1048	601	778
After 30 days ..	1180	477	269	398	1752	855	554	—
After 6 months ..	1258	417	325	376	1674	814	599	601
After 13 months ..	1270	342	—	292	1834	703	577	616

Perhaps the most interesting point emerging from these figures is the low figure for SO_2 in parts per million present in the liquor, flesh, and skins after more than twelve-month's storage. Yet, despite this, the preservation was perfect. After boiling off the SO_2 , the fruit could be used for any normal purpose and there was no flavour deterioration when compared with samples opened after shorter periods of storage.

It should not, however, be concluded that preservation can be effected by commencing with such a low concentration of SO_2 . The high SO_2 content of the stones and the maintenance of a high figure therein during long storage are not, of course, new facts; they were noted in the Long Ashton paper of 1934.

F. Effectiveness of Various Linings for Cold Process Storage Vessels.

In the event of a decision to deal with a heavy plum crop or part of it by the cold process it is clear that the storage problem would have to be solved in advance. The creation of large storage capacity in the plum-growing areas would provide an efficient system for the rapid preservation of a large tonnage of fruit, probably in addition to that tonnage which would be transported away for hot-processing.

The industry's objection that the cold process preserves a lesser amount of fruit per unit of storage space is a real one if only that amount of storage space normally used for the hot process is available. The sulphited pulp is almost entirely held in casks, and since casks have been in somewhat short supply in wartime it is not reasonable to presume that many additional casks could be available for cold processing plums. The scheme envisaged involves the use of concrete tanks lined with a suitable material inert to SO_2 and fruit juice alike. A tank of 300 gallons capacity would hold 1 ton of plums by the cold process compared with 240 gallons to hold 1 ton by the hot process.

Attempts had been made in 1924 to use concrete tanks for this purpose but no suitable lining materials could then be found. A further examination of the problem was made at this Station in 1940 in collaboration with the Low Temperature Research Station, Cambridge, when certain materials were tested and found satisfactory. Amongst these were the following:

- (a) "GaShell" — a black bituminous material which was not affected by the SO_2 and did not impart any taste or colour to the fruit or liquor. This material was tested at Cambridge on two large vats and the preliminary laboratory results were confirmed.

- (b) "Acetas H.H.S."—Good.
- (c) "Durinert."—as for (b).
- (d) Slate—satisfactory.
- (e) Bakelite—as for (d).
- (f) "Nori" tiles—as for (d).
- (g) Bitumen (proprietary grade)—as for (d).

It seems clear that there should be no difficulty in satisfactorily lining concrete tanks to receive cold-processed plums.

While on this point of the use of large tanks mention should be made of the sealing problem. An air-tight closure is essential. This is essentially a constructional problem, but one possible method can appropriately be discussed here; that is, the use of a layer of liquid paraffin. This layer, floating on the surface of the preserving liquor, was shown in small scale tests to seal the plums from the air, but a large scale examination of this method showed that certain precautions were essential.

The plums should be well below the surface of the liquor. The yeasts and moulds are apt to commence their development on the walls of the vessel above the paraffin layer, thus causing a serious local infection at the liquor-vessel surface. Using open-end casks at Long Ashton and a $\frac{1}{2}$ " layer of paraffin considerable infection of this type was apparent in the space of 2–4 weeks.

At the present state of knowledge in regard to the paraffin layer method it is felt that it should be resorted to for tank-sealing only when no mechanical method can be supplied. Finally it should be noted that certain of the above linings were shown to be seriously affected by contact with the liquid paraffin.

G. The Use of the Cold Process Liquor.

During the course of many jam tests made in these investigations it was often debated whether the full amount of liquor proportional to the weight of plums should be used when making jam. Tests showed that the pectin content of the liquor was never high, the major part of the pectin remaining in the flesh of the fruit itself. To quote one specimen test, to each pound of plums 10 ounces of liquor should have been taken, this being the proportion of fruit and liquor in the vessel. The liquor could not be disregarded since during the period of storage considerable solution of the water-soluble matter in the fruit had taken place. Indeed, specific gravities of these liquors in various tests were as follows: 1.022, 1.0245, 1.025.

The use of the full proportional amount of liquor means that a good deal of boiling must be done before the fruit and liquor mass is sufficiently concentrated for sugar to be added. The use of only 25% of the full amount of liquor was tested. With jams made from the more acid varieties, *e.g.* Purple Pershore, this was found to produce a jam of improved character. Of three jams made from the same batch of Purple Pershore plums—(i) from fresh fruit, (ii) from cold process preserved fruit using 100% of the proportional liquor, and (iii) from the preserved fruit using only 25% of the liquor—the last sample was unanimously chosen as the best flavoured by a tasting-panel.

This might be an important point for the jam industry in any re-consideration of the cold process, especially in connection with more acid types of plums. Uses for the residual 75% of the liquor could probably be developed. Samples of this liquor have been evaporated in vacuo at Long Ashton into a dark red, clear syrup with a most attractive flavour.

H. Experiences with Large-scale Employment of the Cold Process.

Over 5 tons of plums were stored in these experiments by the cold process at Long Ashton from the large crop of 1940. For storage in bulk, ordinary 30 and 60 gallon casks were used, these being sealed in the usual manner by a deep tapering bung. The strength of the preserving liquor was initially 1,300 p.p.m., this concentration allowing a margin for loss by leakage over the minimum figure of 1,000 p.p.m.

These casks all kept sound for twelve months. From some of them varying weights of plums were sent to Domestic Preservation Instructresses throughout the country in units of 20 lb. up to 1 cwt. These batches were used by them to demonstrate jam-making methods in the spring and early summer of 1941 when fresh fruit was not available. It is perhaps worth noting that jams with satisfactory sets could be demonstrated with this fruit, a further confirmation of the claim in this paper that the loss of pectin by cold-processed plums is not large enough to prevent proper sets being obtained.

During the warm, late summer of 1941, evaporation of the liquor occurred, presumably through the top staves, and some of the fruit became exposed above the level of the liquor. Also the SO_2 concentration became lower, probably also by loss through the staves. To stop mould infection and to avoid risk of fermentation a second dose of SO_2 equal to that originally given was added, the liquor levels being made up again with water. The fruit remained perfectly sound, and is still in perfect condition six months after the addition of the second SO_2 quota.

I. Cold Processed Plums for Direct Use by Caterers, Canteens, etc.

Although this research was primarily undertaken from a jam-making angle, it should be pointed out that plums thus preserved are eminently suited for normal cooking purposes. Here the comparative loss of pectin would not seem to matter.

The SO_2 can be sufficiently removed by 20 minutes boiling. Figures for SO_2 content after such treatment for various batches of plums originally put down in bulk with 1,000 p.p.m. SO_2 are: 85, 64, 60, and 77 p.p.m. At such low concentrations only palates particularly used to the detection of SO_2 would be aware that the fruit contained any preservative at all. The flavour of plums thus treated and served as stewed fruit was excellent.

It is obvious that a glut crop could not be consumed in season by caterers and housewives even in wartime, but if some of the surplus could be cold-processed and then released in the winter it would be an invaluable addition to the wartime diet. Casks or large jars of cold-processed plums could be distributed to grocers or fruiterers; with some publicity to ensure that this fruit was boiled for at least twenty minutes before serving—in any case a normal part of cooking procedure—there seems little doubt that caterers and housewives would in wartime be only too ready to bring their own jars and purchase portions of the preserved plums. Works canteens would be able to purchase large bulks of the fruit. During these experiments at Long Ashton it has been found that casks and jars of cold-processed plums will keep sound for several days after opening, and it seems certain that, if such a scheme was undertaken, the demand would be sufficient at any shop with a large number of customers to clear a cask or large jar within such a period. With the

increasing short supply of tinned fruit such a scheme seems worthy of very thorough consideration if a plum surplus should materialise.

Summary.

1. The cold SO_2 method of preservation of plums has been further examined. Whilst greater losses of pectin occurred in the cold process than in the hot pulp process, it has been shown that, despite this loss, satisfactory "sets" were obtained in all jams made from the cold processed fruits.

2. No significant differences in efficiency of preservation were found in samples treated with liquors containing 800-2,000 p.p.m. SO_2 .

3. Immature, ripe and overripe plums were all efficiently preserved by the cold process. The variety of plums appeared to have no effect on the preservation process.

4. The distribution of SO_2 in the skins, stones, flesh and preserving liquor were examined over a 14-month period. Certain well defined trends were observed in the SO_2 contents of the various tissues. The SO_2 content of the liquid fell to 220-260 p.p.m. after 14 months, yet preservation was still effective.

5. Various materials were tested and proved suitable as linings for vessels in which to store the preserved plums. The use of paraffin oil as a liquid seal to prevent access of air is discussed.

6. The use of the whole or a part of the preserving liquor in the jam making process is considered. Jams made from high acid plums have lower acidities if only 25% of the liquor is used. A method of utilising the residual liquor is suggested.

7. Details of the cold process preservation of 5 tons of plums are given.

8. The possibility of disposing of plums preserved by the cold SO_2 process to caterers and housewives is discussed.

MALIC ACID AS A BY-PRODUCT IN THE PRODUCTION OF APPLE TREACLE.

By VERNON L. S. CHARLEY, D. P. HOPKINS and A. POLLARD.

A comprehensive study of the problems involved in the production of apple treacle was published in the Annual Report for 1940 (p. 97).

This second paper deals with the removal of malic acid from concentrated apple juice.

A. Preliminary Experiments.

The need to reduce the acidity of most types of apple juices before concentration to treacle has been reported and it would seem to be essential if the product is to possess the true sweetening value of its natural sugar content. In the earlier experiments use was made of K_2CO_3 but since potassium salts were becoming more expensive attention was given to the use of pure precipitated chalk. Although mixtures of the two carbonates were used at first, the potassium salt was not added in any of the later work.

It was thought that the use of the calcium salt would constitute an advantage since calcium malate is comparatively insoluble. Where the potassium malate had remained in solution in the treacle, the calcium salt should wholly or substantially precipitate out. Throughout it has been considered desirable to remove the malate formed during neutralisation; for, although the treacles had lost most of their natural acidity and thus enhanced their sweetness, a saline flavour had developed which could be detected on the palate as an objectionable background taste. Whilst it was not anticipated that this would affect the use of the treacle as a sweetening agent when diluted with other food materials which would tend to mask this particular flavour, it was noticeable when the treacle was consumed alone. The saline taste, however, was preferable to a high acidity. With treacle made from juices of high acidity, such as Bramley's Seedling, the problem of neutralisation and salt removal was even more important. If a potential acidity of 10% in the treacle is reduced by preliminary neutralisation to 1%, there will be approximately 9% of calcium malate left in the treacle.

In the first experiments, however, the precipitation of calcium malate did not take place. Even in concentrates and treacles, where the degree of neutralisation has been quite large, only slight deposits were noted after several weeks of storage, and appeared to be composed largely of flocculent materials. It seemed that the capacity of calcium malate to remain in solution in quantities much greater than its accepted solubility was very considerable. The reason for this was obscure, until it was realised that its separation from solution depended upon two main factors, *i.e.*, absence of free acids in solution and the temperature. Whilst the neutral salt has a low solubility in water which decreases with a rise in temperature, the acid salt, calcium hydrogen malate, has a high solubility which increases with a rise in temperature. Consequently if part of the malic acid is left free in solution, it can react with a corresponding amount of the neutral salt to give the more soluble acid salt which will remain in solution. At temperatures above 60°C, however, the

acid salt apparently gives rise to the neutral salt, calcium malate, and free malic acid, the former being thrown out in solution. When the partially neutralised juice was concentrated in a vacuum evaporator, a sufficiently high temperature was not attained for rapid precipitation to take place. Much of the malic acid was therefore still present as the soluble acid salt. The fact that the rest of the malic acid present as the neutral salt did not separate may be attributed to supersaturation of the highly viscous concentrate, for the juice which had been almost completely neutralised showed a similar behaviour. A similar phenomenon in simple aqueous solution is discussed in the literature (1).

At this stage, it was desired, with a view to domestic preparation, to produce an apple treacle by open pan boiling and not by vacuum evaporation. In view of the high acidity (0.77%) of the juice used, neutralisation to 0.1% (as malic acid) had been carried out with CaCO_3 . In sharp contrast to the experience with vacuum-produced treacle and concentrates, the calcium malate showed no tendency to become supersaturated. When the juice reached a concentration of 1.200 after considerable boiling, a heavy precipitate of calcium malate appeared and settled rapidly on standing. This precipitate could be readily separated by decanting the liquor from it, or better still by centrifuging.

It appeared, therefore, that the disturbance of the state of supersaturation could be brought about by heat. This point had not been apparent before solely because the temperature of the concentrate never rose above 60–65°C in the vacuum evaporator. Samples of vacuum evaporated concentrates which had been almost neutralised were next heated in open vessels. At 70–75°C, and more markedly on reaching boiling point, bulky and crystalline precipitates appeared. The resulting liquids, freed from these precipitates by decantation, centrifugation or filtration, had lost their saline flavour. Further, the calcium salts could be used for the preparation of malic acid.

The actual method of the separation of the calcium salt and the preparation of malic acid are described below.

B. Open Pan Boiling.

(i) *Neutralisation.*

30 gallons of Bramley's Seedling juice (acidity 0.7% malic acid) were treated with 18 oz. of precipitated chalk, added gradually with stirring. After standing for 18 hours the dark brown juice was pulp-filtered and concentrated in an open steam pan to a volume of 2 gallons. The resultant treacle was decanted from the heavy crystalline precipitate which had separated and was filtered free from solids through several thicknesses of muslin.

(ii) *Purification of Calcium Malate.*

The precipitate was mixed with a small volume of hot water and filtered with suction to remove the bulk of the adhering treacle, and the solid material was then ground with successive portions of hot water and filtered. 690 gm. of a light brown crystalline powder were obtained with an ash content (as CaO) corresponding to 83% anhydrous calcium malate. The yield of calcium malate was 70% of that calculated from theoretical considerations.

(iii) *Isolation of Malic Acid.*

The crude calcium malate was washed again with hot water, filtered off and dried to a light grey powder. The titratable base in the ash corresponded to a purity of 90.5% as the anhydrous salt, or 103% as the lower hydrate (with $1\frac{1}{2}$ molecules of water). 300 grm. of this salt were ground to a thick paste with 600 cc. water and 156 — of 98% sulphuric acid in 200 cc. water gradually stirred in. After standing over night the sludge of calcium sulphate was separated in the centrifuge the supernatant solution collected and the deposit ground with hot water and centrifuged several times. The combined light brown washings (2 litres), after treatment with charcoal, gave a light yellow solution containing titratable acid equivalent to a 91% yield of malic acid. Concentration in vacuo to 250 cc. caused the separation of a small amount of CaSO_4 which was filtered off; after further concentration to a thick syrup the solution was allowed to stand overnight when malic acid commenced to crystallise out. Three crops of crystallised material were obtained, viz. 70 grm. (m.p. 97–100°C); 88 grm. (m.p. 95.96°C); and 18.5 grm. of crude material with a lower m.p.

(iv) *Analysis of Malic Acid Material.*

(a) A specimen recrystallised from water gave very pale yellow, granular crystals with a melting point of 100–101°C. No depression of melting point was observed when the material was mixed with authentic *l*-malic acid of the same melting point.

(b) The equivalent weight by titration was 67.3 (theoretical=67.0).

(c) Estimation by method of Pucher, Vickery and Wakeman (2) gave the purity as 98.5% malic acid.

C. From Vacuum Boil Process.

As an example of the separation of the malate from a vacuum produced neutralised concentrate which had retained all the salts in solution for some considerable period, one experiment may be given. A concentrate of specific gravity 1.350 was brought to the boil at atmospheric pressure on which an immediate separation of crystals occurred. Separation was easy and the precipitate was obtained, after washing and drying, as a light grey powder. Continued heat treatment after the precipitate had been removed produced further slight precipitation but the granular nature of the precipitate rendered it easy to remove by filtration.

D. Treatment of Juice by Combined Vacuum and Open Pan Evaporation.

An experiment was carried out in which a large bulk of Bramley's Seedling apples from Kent was milled and pressed and the juice neutralised with CaCO_3 to 0.07% malic acid, and subsequently centrifuged and filtered. 40 gallons were concentrated on the Kestner plant to a gravity of approximately 1.250 and no precipitation of calcium malate occurred; this concentrate, however, was then boiled in an open pan. At 70°C and above, the expected deposition of calcium malate took place. The entire bulk of this crystalline precipitate was separated easily from the concentrate by decantation and filtration. The concentrate, thus freed from precipitable malate salts, was then fed to the Kestner and gently evaporated in vacuo until the treacle stage was reached. Only a slight further deposition of malate material took place and this settled out at the bottom of the treacle containers

within a few days, despite the high viscosity of the liquid phase. In a very thick treacle this settling out might take a long time so that high gravity treacles should not be aimed at when malate removal is being conducted.

Some of the remaining neutralised juice was concentrated in the Kestner evaporator by the Long Ashton two-stage method to treacle without the intermediate open pan boil: in this case no deposition of calcium malate occurred during the processing, though after some months of storage a slight precipitation of crystalline material was observed on the walls of the storage vessels. How much calcium malate is self-precipitated from concentrated neutralised apple juice products over long storage is obscure; but this slight deposition in the cold has been noted only occasionally and then in concentrates made from very heavily neutralised juices, *i.e.* where the malate concentration is high. This particular treacle was stored in an unheated place and it is possible that the precipitation was started by some sudden lowering of temperature.

The remainder of this bulk of neutralised juice was evaporated in an open-pan by external steam heating. At a convenient half-way stage, when a gravity of about 1.200 had been reached, the juice was removed and the bulk of precipitated calcium malate separated; the evaporation was then continued and a final separation of further precipitate was made when the final treacle was still warm. Separation, however, was not quite so easy in this case as the crystals of malate produced in the open-pan evaporation seem to be of a finer texture. For perfect separation a filter suitable for thick syrups or treacles would have to be employed as a final treatment. This was not possible at Long Ashton so the last traces of malate had to be separated by allowing them to fall to the bottom of the storage jars and then carefully pouring off the treacle.

These three treatments of the same juice produced three quite different treacles, as is shown by the following data:—

		A	B	C
		Vacuum Process without malate removal.	Vacuum Process with malate removal.	Open-Pan Process with malate removal.
Specific Gravity	..	1.377	1.385	1.375
Soluble Solids %	..	80.5	77.2	75.8
Acidity %	..	0.65	0.60	0.40
Invert Sugar %	..	41.3	45.2	45.1
Sucrose %	..	11.9	10.0	12.1
Total Sugars %	..	53.2	55.2	57.2
Colour	..	Light brown	Darker brown	Very dark
Consistency	..	Very viscous	Very viscous	Thicker than A or B
Flavour	..	Very sweet with pleasant apple flavour. Back- taste of a saline material	Like A but with no saline back-taste	Pronounced caramel- ised flavour. Loss of apple character. Very similar to West Indian treacle

The flavour differences between the open-pan and vacuum products were so marked that the samples could hardly be satisfactorily compared. Which of the products is favoured will be an individual matter; some prefer the true apple character, whilst others will, no doubt, prefer the strong, full-bodied flavour of the open-pan boiled product.

An experience with another treacle made during this experiment should be mentioned. Even when very efficient filtration apparatus was used the crystalline malate when first separated was not free from adhering concentrate or treacle. The method of decantation and subsequent filtration through several thicknesses of muslin as performed in the other experiments increased the tendency for treacle to adhere to the crystals. The first operation in purifying the malate, therefore, was to wash with hot water. Bulking all the precipitates obtained, the first washings with water yielded 10 gallons of weak concentrate with a gravity of 1.135. This was boiled down to produce a treacle of the following analysis:—

Specific Gravity	..	..	..	..	1.352
Acidity	..	..	..	..	0.56%
Total Solids	..	..	..	..	73.3%
Invert Sugar	..	..	..	..	41.5%
Sucrose	..	..	..	..	10.1%
Total Sugars	..	..	..	..	51.6%

While this treacle was not comparable with the others, the possibility of converting some of the otherwise waste material into a product of somewhat lower quality cannot be ignored.

E. Commercial Significance of Calcium Malate Removal.

Where apple concentrate and treacle are made from cooking apples, and where arrangements can be made to use the fruit before an appreciable loss of acidity has taken place, the acidity of the expressed juices may be taken as approximately 1% malic acid. 100 tons of such apples would yield about 150,000 lb. of juice and, if the neutralisation is taken to 0.1%, this will result in the removal of about 0.8% malic acid. Until the commercial experiments have been carried out, no definite figures can be given, but it is probable that 1,000 lb. malic acid could be prepared in a highly pure condition from the 100 tons of apples. *l*—Malic acid is quoted at 15/6 per lb. (January 1942) at which price the yield of acid would be worth a relatively high sum, but even if the acid were compelled to compete with tartaric or citric acids, at much lower prices, it should still be economical to produce it either as a crystalline acid or a heavy syrup. It must be emphasised that the salts separated by this method can be regarded, like the pomace residues, largely as by-products; the main product is the apple treacle. The commercial production of malic acid by this process is now being examined at Long Ashton.

It is possible to separate the highly concentrated boiling treacle from the precipitate by simply pouring through four thicknesses of muslin. However, this procedure results in a considerable amount of treacle adhering to the crystalline mass and it is probable that the separation of the major part of the malate salt would be more efficiently done at a slightly lower gravity of 1.350–1.380, when the concentrate is more fluid and would separate from the crystalline sludge more completely and require much less washing to complete the removal of the sugar material. In this case, it is suggested that the fresh juice could be advantageously evaporated in vacuo to a gravity

of 1.350–1.380, and then heated under atmospheric pressure to a much higher temperature until the greater part of the crystals have separated. The concentrate can easily be decanted from the calcium malate and the final stage of evaporation carried out in an open pan. By this means a large proportion of the malate can be removed from the less viscous concentrate leaving only a very minor quantity to be separated from the final treacle.

An application has been made for a patent in respect of the process.

Summary.

1. A method is described whereby malic acid can be isolated from the crude calcium salts obtained in the evaporation of neutralised apple juices.
2. The conditions required to obtain precipitation of the salts are given.

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THE UTILISATION OF SURPLUS CARROTS.

A. PRODUCTION OF TREACLE.

B. POMACE AS A FEEDING STUFF AND SOURCE OF PECTIN AND CAROTENE.

C. FERMENTATION PRODUCTS.

By VERNON L. S. CHARLEY, D. P. HOPKINS and A. POLLARD.

In the winter of 1940-41 it became apparent that the carrot crop had provided one of the few surpluses in the country. It seemed, therefore, desirable to investigate the possibilities of converting carrots into food products of greater stability and less bulk than the carrots themselves; for although carrots can be kept in a sound condition for some months, it was clearly shown in 1941 that the carrot crop, even when available over a period of some months after raising, could only be partially consumed as carrots by the public. Also, the problem of non-keeping carrots, such as "splits," seemed to merit attention, for most carrot growers inevitably produce an appreciable percentage of "splits," and these will not keep for any length of time. Conversion of such carrots into more stable products, therefore, had an even greater urgency.

On the lines of previous work with apples and plums (Long Ashton Annual Reports 1939, p. 116, and 1940 pp. 97 and 115) the production of a carrot treacle and of carrot pomace was fully investigated both on the small and large scales. Substantial progress was made, and as a result it was possible to formulate a scheme by which large quantities of carrots which would otherwise have gone to waste could be converted into stable products. The value of carrot juice as a fermentable material was also examined.

An experiment on 390 tons of carrots was supervised in Somerset and Devon cider and milk factories by the Products Section of the Research Station on behalf of the National Vegetable Marketing Company in March-April, 1942, but the results are not yet complete.

A. PRODUCTION OF TREACLE.

In the course of earlier tests an attempt was made to dry carrots after milling in an ordinary cider-mill, but the amount of moisture present was too great. By first pressing out the juice from the milled carrots, a residue was obtained which could be dried as freely and efficiently as ordinary apple pomace, and in the pressing operation a much greater yield of juice was given than might have been expected. This suggested that perhaps the best method for treating surplus carrots in quantity would be to press out and concentrate the juice and dry the residual pomace, a similar processing scheme to the Long Ashton apple treacle process.

Any reasonably efficient cider mill will reduce whole carrots to a pulp with ease. No previous hot water treatment is necessary to soften the carrots. In view of the general condition in which large loads of carrots are received

from growers, however, it is advisable to wash and hose the roots before milling ; if this is not done the dried pomace is apt to be gritty.

The yield of juice from Somerset carrots is best illustrated by the following figures from actual large-scale tests. Hydraulic pressure up to 2,000 lbs. per square inch was applied.

Test.	Carrot Condition, etc.	Gallons of juice per ton.	Specific gravity of juice.
Test 1 April, 1941 ..	Bad. Much deterioration after long storage. One ton milled	112	1.030
Test 2 December, 1941 ..	Good condition but high percentage of splits. 5 tons 4 cwt. milled	160	1.033
Test 3 December, 1941 ..	Condition as for Test 2. 2 tons 2 cwt. milled ..	164	1.033
Test 4 December, 1941 ..	Small under-sized roots. Good condition. 5 tons milled	140	1.031
Test 5 January, 1942 ..	Condition as for Test 4. 2 tons milled	150	1.030

In addition to these figures many small-scale, laboratory hand-pressing, extractions of juice have been made, and even by these somewhat less efficient methods of pressing, yields that correspond to between 120 and 130 gallons per ton have been regularly obtained. The low yield in Test 1 was undoubtedly due to the condition of the carrots. It should, however, be made clear that in none of the other tests was the condition of the carrots used above average. Furthermore the weights given are the weights of carrots *before* washing, and it was found on one test that the removal of dirt involved a loss of 5 lb. per 1 cwt.

It seems, therefore, quite safe to state that a yield of 140 gallons per ton of Somerset carrots can be expected by milling in an ordinary apple-grater type mill and using adequate hydraulic pressure. A second pressing was always undertaken in the Long Ashton tests, the 140 gallons being obtained from the two operations respectively, as 120 gallons and 20 gallons. The variation in yield with variety, size, climate and soil conditions has not yet been examined.

The gravities of all carrot juices examined in the many Long Ashton experiments, both small- and large-scale, have fallen between the limits of 1.030 and 1.040. This would seem to apply to carrots just after lifting and to carrots that have been stored some months. Variations in gravity such as are met with in apple and other fruit juices do not seem to be displayed by the carrot, but there appears to be a well-defined drop in gravity in carrot juice at the end of the season, especially when the roots commence to grow out. The acidities of the juices are invariably very low ; 0.04—0.1% (expressed for convenience as citric acid) are representative figures. The pH of carrot juice seems to vary very little from a figure of 6.20. The juice is strongly buffered, and unexpectedly large amounts of organic or mineral acids are needed to lower the pH.

(a) **Clarification of the Juice.**

The condition of the juice when expressed is far from satisfactory. It is much thicker than raw apple juice, and carries more suspended, dispersed and colloidal matter. In this state it cannot be filtered and even slow centrifuging will remove only a small percentage of the suspended matter. It has a dark, almost "oily" appearance.

Pectin-decomposing enzymes failed to achieve any clarification, and the lack of clarity in the juice hardly seemed a problem connected with pectin content since analyses of carrot juices had shown that such pectic substances as were present were of the degraded pectin type rather than true pectins.

An exhaustive examination of enzyme methods of clarification has not been made on carrot juices, but of those tried none was successful. The enzyme method of approach was given up when it was found that a very easy and efficient clarification could be achieved by simple heat treatment. With all carrot juices so far examined, raising the temperature to 160°F. brings about a sharp and heavy precipitation of nearly all the suspended matter present, both free and colloidal. Approximately 160°F. is the temperature at which this action commences, but on the large scale it is necessary to continue the heating until the juice boils or almost boils. To give a margin of safety for full precipitation it has been found best to hold the juice at its maximum temperature for fifteen to thirty minutes. The further period of heating seems to serve two purposes: the precipitation is effected as completely as possible and the precipitate is coagulated into a surface layer which can be almost entirely removed by simple skimming. The precipitate is reddish-brown and very light.

It is believed that this deposition is a "precipitation" of colloidal proteins and allied substances and not a chemical precipitation of any of the dissolved constituents of the juice. Similar behaviour by proteins is, of course, well known, *e.g.* the heat-induced coagulation of albumen in egg-white and the precipitation of colloidal casein by pH alteration. It seems to be entirely a heat-induced change in carrot juice, for the pH of the juice shows no appreciable change following precipitation: nor have pH alterations in the cold induced the same action, though this line of enquiry has not been exhaustively studied. At 160°F. and upwards the particles of the colloidal matter seem to coagulate rapidly until the colloidal system becomes unstable. The more rapidly the heating is effected the better is the coagulation. (This property has been found to be possessed by the expressed juices of other vegetables, *e.g.* swede and cabbage juices, similar precipitates appearing sharply and in considerable bulk at about 160°F.)

In large-scale tests there has been no difficulty in using this property to effect clarification. Batches of juice up to 500 gallons have been pumped into steam-jacketed tanks (such as are used in the cheese industry), and the temperature raised as rapidly as possible by live steam injection to just below boiling-point. Carrot juice tends to froth rather excessively on boiling so that careful control of the temperature and heat-supply is necessary unless there is considerable head-space for expansion above the normal liquid level. The frothing, if kept under control, is advantageous, for it carries the light, precipitated coagulum well up above the true surface of the liquid and its removal by skimming can be carried out with very little loss of juice. It is best to

skim in one careful operation after the period of maximum temperature has been completed, as by that time the total precipitate should have formed on the surface. The juice left after skimming is dark brown to amber in colour, and sufficiently clear for most purposes. To obtain perfect clarity, filtration through pulp or cloth, or centrifugation, is necessary, though the latter operation has been found sometimes impossible at Long Ashton owing to the heavy frothing of the warm juice. A "brilliant" carrot juice, comparable to a de-pectinised and pulp-filtered apple juice, has not yet been produced; but for the preparation of concentrates or treacle the degree of clarity brought about by skimming and pumping out of the tank through muslin, if necessary, is quite sufficient. In one or two batches of carrot juice it was found that a small percentage of precipitated matter fell to the bottom of the tank. This was removed by running the liquid out of the tank through a fine-mesh metal gauze and then through one thickness of fine-woven cloth.

Concentration of clarified carrot juices by vacuum and open-pan methods has been successfully accomplished, no particular difficulties being experienced in any test. The open-pan process is rather lengthy for two reasons; in the early stages heat has to be applied gently to control frothing, and in any case the degree of concentration required to produce the necessary increase in specific gravity involves evaporation from 13 or 17 volumes down to 1 volume. Neither the vacuum product nor the open-pan product retains any noticeable carrot flavour. The vacuum product is extremely sweet and the open-pan product has a more characteristic caramelised and toffee-like flavour.

The following analyses of three different batches will indicate the possible value and use of this kind of product:—

Vacuum Concentrates made in a Batch Vacuum Evaporator in a Somerset Factory.

			A	B
Specific gravity	..	..	1.350	1.378
Acidity (expressed as citric)	..	..	0.416%	1.37%
Sugars. Total	..	..	56.8%	57.9%
Invert	..	..	28.1%	20.4%
Sucrose	..	..	28.7%	37.5%

Open-Pan Concentrate made at Long Ashton.

			C
Specific gravity	..	..	1.353
Acidity (expressed as citric)	..	..	1.31%
Soluble solids	..	..	71.6%
Ca pectate	..	..	Nil
Sugars. Total	..	..	45.2%
Invert	..	..	27.4%
Sucrose	..	..	17.8%

NOTE.—Sample C was made from the juice of Test 1 (see above). These carrots had been stored for some time and probably the somewhat low sugar content was due to this. This batch of carrots represented the lowest standard of condition in which carrots could be handled for processing. A further week of storage would have resulted in their complete loss.

It must be emphasised that the clarification and concentration of the juice must be carried out as quickly as possible after the juice is expressed. Irregular fermentations due to soil and other organisms are likely to arise in

the course of a few hours and on no account should an interval of more than 12 hours elapse between the pressing and heating treatments.

The only known food value present in these concentrates appears to lie in their sugar content. The carotene in carrots remains in the press-cake, carotene being water-insoluble; and carotene removed with the juice is attached to the suspended colloid particles and is therefore removed when clarification takes place.

Samples of carrot treacles and concentrates have been examined by many food manufacturers, particularly in the confectionery, bakery and pickling trades. As an additional source of sugar these products have met with almost unanimous approval and very large quantities could be used provided the concentrates could be marketed at an economic figure. The price of carrot treacle, however, depends largely upon the price paid for *surplus* carrots, a matter outside the sphere of the writers.

(b) Pomace as a Feeding Stuff and Source of Pectin and Carotene.

In costing the above scheme for dealing with carrots the price-return for the concentrated juice is not the only consideration. The press-cake when disintegrated and dried provides a food-stuff of undoubted value. It is comparable in texture with dried apple pomace, and pomace driers can produce it from the carrot press-cake without any applicable departure from the usual conditions for the apple product. It has three possible uses :—

- (i) As a cattle feeding-stuff.
- (ii) As a source of pectin.
- (iii) As a source of carotene.

(i) Cattle Food.

For cattle-feeding the pomace has, according to analysis, a value equal to that of dried sugar-beet residues. This estimate is based upon the assumption that the produce will, by the time it is used, have lost its carotene by oxidation; pomace used soon after production would, however, retain a good deal of its carotene and would therefore be of much greater value. Gas or vacuum-packing is, of course, not applicable to a cattle-feed, but the possibility of devising methods of packing that would prevent or reduce the loss of carotene is being examined; success in this direction, however, seems rather improbable at present. Analysis of two samples of carrot pomace are as follows :—

- A. Sample made in April, 1941, and not analysed until six months later.
- B. Sample made in December, 1941, and analysed within one month.

	A	B.
Moisture	10.07%	11.66%
Crude Protein	7.66%	6.04%
Crude Fibre	15.58%	15.76%
Total Ash	9.56%	11.52%
Ether Extract	0.81%	1.01%
Carbohydrates (by difference) ..	56.32%	54.01%
	100.00%	100.00%

(ii) Pectin.

The possibility of extracting pectin from carrots had been considered many years ago, but the yield and quality of the pectin was found to be

considerably below that from apple pomace. Some preliminary tests carried out at Long Ashton in 1941 confirmed this, but in view of the shortage of apple pomace in the autumn of 1941, due to the very small crop, some further experiments were carried out to determine whether the pomace produced as a by-product in the carrot treacle process could be regarded as a useful source of pectin. Samples of dried pomace produced on the Simon drier at Long Ashton were supplied to various firms producing pectin and to the British Association of Research for the Cocoa, Chocolate, Sugar, Confectionery and Jam Trades. It is sufficient in this connection to say that the results of laboratory and semi-commercial tests indicate that pomace dried under carefully controlled conditions possesses about one-half to one-third the value of good apple pomace. Certain alterations in pectin extracting methods are essential, but it would appear that in the event of an acute shortage of the apple material carrot pomace could be usefully employed as a substitute.

(iii) *As a Source of Carotene.*

As practically the whole of the carotene present in the carrot is to be found in the pressed pomace, this product could serve as a readily accessible source of carotene and therefore indirectly of vitamin A. Some loss of carotene occurs, however, during the process of drying the pomace, values for the retention having been found to lie between 60% and 80% in a number of large-scale operations. The retention varies according to the conditions under which drying is carried out. The carotene in the dry pomace is stable in the absence of air, but as the pomace is in a finely divided state, oxidation of the carotene takes place when the material is stored in air for any length of time. Similar storage effects have been found in other materials rich in carotene, as for example, dried grass. The loss of carotene in pomace stored in air in stoppered jars is shown by the figures given below:—

				Carotene (mg./100g.)
Original material	..	..	..	95
After 10 weeks	..	..	..	42
After 34 weeks	..	..	..	10

Package of the material in sacks or in water-proof paper bags resulted in similar losses, but package in nitrogen prevented any appreciable loss.

				Carotene (mg./100g.)	
				(1)*	(2)*
Original material	..	..	..	144	76
After 8 weeks in sacks	..	..	..	34	38
„ „ „ „ bags..	..	..	..	36	42
„ „ „ „ nitrogen	..	..	..	133	76

(1)* and (2)* were prepared from different batches of carrots.

Although the carrot pomace has value as an animal feeding stuff apart from its carotene content, to use it to the best advantage its high carotene content should be utilised. This may be accomplished by using it for this purpose within a short time of its production. The apparent loss in gas-packed material shown by sample (1) was due to time elapsing between production and packing in a nitrogen atmosphere.

Alternatively, the pomace may be used essentially as a source of carotene, to replace vitamin A at any rate in part, in vitamin concentrates, or in the fortification of foodstuffs. As a source of carotene, carrot pomace has advantages over dried grass, which has been recommended for this purpose.

Thus, although the green leaf offers a readily available raw material, the presence of chlorophyll and large amounts of lipid material makes necessary processes of separation and purification which are not required when carrot material is used, chlorophyll being absent and lipoids present only in traces.

Crystalline carotene is readily obtainable from the freshly pressed wet pomace by the conventional method of extraction with acetone followed by extraction with petroleum. On removal of the acetone by the addition of water, followed by the concentration of the petroleum solution, carotene crystallises out, the separation being facilitated by the addition of alcohol. Dried carrot pomace has of course advantages over the wet material from the point of view of ease of transport and stability. Carotene may be extracted from it by petroleum or other suitable solvents, the extraction being facilitated by previous grinding of the material. The most suitable conditions for carrying out the extraction have not yet been studied in detail, but it has been difficult to prepare reasonably pure samples of crystalline carotene from pomace which has been stored for several months.

Preliminary experiments on the production of carotene concentrates in solvents have shown that the carotene in wet, pressed carrot pomace may be extracted by the admixture of a small amount of edible oil such as arachis oil*. The oil containing the carotene is separated by a short extraction with light petroleum or by the addition of petroleum followed by pressing. (The carotene in the wet pomace is not efficiently extracted by petroleum alone.) Removal of the petroleum under slightly reduced pressure leaves a dark red oil solution of carotene, the concentration possible being limited by the solubility of the carotene: *e.g.* a solution containing 5 mg. of carotene per 1 g. of oil deposited crystalline carotene on standing at room temperature.

(c) Fermentation Products.

Large and small scale experiments were carried out. Raw carrot juice, carrot juice which had first been clarified by heat treatment (see above), and juice with its pH lowered to approximately 3.20 by hydrochloric acid addition were allowed (a) to ferment naturally and (b) to ferment after the addition of cider yeast.

Only in the case where the pH had been lowered did a fermentation to dryness occur. In the other cases the fermentation was initially extremely rapid, but ceased abruptly before dryness was reached.

Very high increases in acidity were associated with these partial fermentations, and much of this acid was found to be volatile. Thus a fresh carrot juice showed a gravity of 1.031 and total acidity of 0.05% (as malic acid). After fermentation the analysis was as follows:—

Specific gravity	..	..	..	1.015
Total acidity (as malic)	..	..	..	0.76%
Volatile acidity	..	..	..	0.29%
Alcohol	..	..	..	0.26% (by weight)

So far in these experiments it seems that a fermentation process comparable with that of apple juice is only to be obtained by lowering the pH.

Even when this is done, however, and the fermented material clarified, the taste and character of the product are not satisfactory. A specific and peculiar flavour has been pronounced in all samples of these fermented juices, although fermentation in the presence of apple juice appears to give a better flavour.

* The oil used was kindly supplied by Messrs. Lever Bros., Ltd.

Summary.

1. A process has been developed and carried through to large scale commercial practice whereby carrots are processed into a concentrated juice (treacle) with 50—60% natural sugar, and a dried pomace.

2. The pomace can be used as an animal feeding stuff having apparently the same nutritive value as dried sugar beet residues. The dried pomace has from $\frac{1}{3}$ to $\frac{1}{2}$ the value of apple pomace as a source of pectin, but special conditions of extraction must be observed. The carotene in the freshly dried pomace can be extracted in various ways by organic solvents or arachis oil.

3. Carrot juice has been allowed to ferment under different conditions, but the ultimate products have not been satisfactory from a flavour point of view.

Acknowledgment.

The writers wish to express their appreciation of the collaboration given in analytical work by Miss M. E. Kieser.

INVESTIGATIONS ON THE USE OF ROSE-HIPS AS A SOURCE OF VITAMIN C.

I. A REVIEW OF THE EXISTING LITERATURE.

By V. E. SILLS.

For a number of years the fruit of the wild rose has been known as a very rich source of vitamin C. Compared with the rose-hip, most other fruits, wild or cultivated, and with the exceptions of the blackcurrant and citrus fruits, contain but small amounts of this very important vitamin. It is therefore not very surprising to find that during the first two years of the war much attention has been paid by research workers throughout Europe to the subject of rose-hips and rose-hip food products.

In order to fulfil the growing need for information concerning the nature and preparation of rose-hip products in this country it was decided to compile a brief review of all the published work directly associated with this subject. Unfortunately, not all the scientific papers on rose-hips are available in this country and therefore the review is not as complete as was hoped. In certain cases it has only been possible to examine abstracts of original papers, passages of which have been cited.

Much of the latest information concerning the utilisation of rose-hips is of Scandinavian and Russian origin. It appears that species of wild rose are prolific in certain regions of these countries and it is quite understandable that considerable advances should have been made in the preservation of the fruits and preparation of hip teas and soups as a substitute for citrus juices. Even before the present war broke out, rose-hip teas and soups were being recommended in hospitals as a source of vitamin C for young children.

In this country a small number of scientific contributions to the subject of rose-hips has appeared during the last two or three years and more recently a considerable amount of publicity through the medium of the newspaper press and wireless has been given to the virtues of the rose-hip.

The first part of this scientific review contains short references to the vitamin aspects of rose-hips and includes in abbreviated form some of the conclusions drawn by individual authors. The second part deals at greater length with the more important investigations which are grouped under separate sections so that a closer comparison of results and conclusions may be drawn.

Zarins and Putnina (1) (1939) examined a number of different species of hips and discovered a wide variation in vitamin C content. They also noted that there was no loss of vitamin C on storing hips for a long time in the dark and at a low temperature. Gedda and Kjellberg (2) (1939) found a high vitamin C content in fresh hips, viz., 454–833 mg. per 100 g. and a lower figure in dried fruits, viz., 333 mg. per 100 g. Besaric and Rikovski (3) (1939) found 20–150 mg. vitamin C per 100 g. pulp of immature hips rising to 460–1000 mg. ascorbic acid per 100 g. in the mature fruit. Drying resulted in a loss of ascorbic acid amounting to 60–80% after storage for 1–2 years. No loss was incurred when pulped hips were boiled for 45 minutes with an equal weight

sucrose and the vitamin C content of the jam so prepared did not fall during prolonged storage. Hammar and Schröderheim (4) (1939) described the variation of ascorbic acid content of fresh fruits. By oven-drying the hips in presence of air, 60–70% of the ascorbic acid was destroyed, but this could be largely avoided by special means. Powdered, dried hips were shown to be inferior to whole dried hips. Improvements in the preparation of teas and soups were described. A review of the work done on rose-hips previous to 1939 is included by Hammar and Schröderheim in the introduction of their paper and because of its value it is reprinted here: “v. Hahn (5) (1931) found 100 guinea pig units of vitamin C per 100 g. (0.05%) of dried and cooked rose-hips. Tillmans, Hirsch and Vaubel (6) (1933) prepared pure ascorbic acid from rose-hips and obtained 5.7 g. ascorbic acid from 35 kg. fresh hips. Lund, Spur and Fridericia (7) (1934) determined the ascorbic acid content of dried rose-hips by biological and chemical methods and obtained 1.4% by both methods. Strohecker (8) (1935) found 88–106 mg. ascorbic acid in 100 g. green harvested hips in the months June–August, but 290 mg. in 100 g. ripe hips in September. Jarussowa and Schepilewskaja (9) (1936) observed that the smallest dose of dried rose-hips in the prophylactic guinea pig experiment amounted to 25–50 mg. per day, corresponding to an ascorbic acid content of 1–2%. By means of titration, the same authors found 1.3% ascorbic acid in dried and 2% in fresh, seed-free hips. Gudlet and Kardo-Syssojeva (10) (1937) showed that only about 10% of the total ascorbic acid in a rose-hip test (780 mg. 100 g.) was reversibly oxidised. Mathiesen (11) (1937) found 1.3% ascorbic acid in fresh rose-hips and Winckelmann (12) (1938) 0.4% in fresh rose-hip flesh.”

Svensson (13) (1936) determined the vitamin A content of rose-hips and records 6 mg. β -carotene per 100 g. rose-hip flesh. Callegari (14) (1939) found a vitamin B₁ content of 0.6 i.u. per g. of dried rose-hips by the thiochrome method but addition of the fruit to a vitamin B₇ free diet accelerated the onset of polyneuritis in pigeons.

Goldberg and Walsh (15) (1938) assayed rose-hips during different stages of ripeness and also after drying at certain temperatures. Andross (16) (1941) analysed a wide selection of British wild fruits, including the rose-hip at successive stages of ripeness; a number of jams, purees, etc., were prepared and examined. Melville and Pyke (17) (1941) have compiled a valuable and comprehensive list of British and foreign roses cultivated at the Royal Botanic Gardens, Kew, and the Royal Horticultural Society's garden at Wisley, in which a complete vitamin C assay of the fruits is given. Loewenfeld (18) (1941) described the domestic method of drying hips and the preparation of jam, soup, sauce and tea.

Fuller details of some of the above work will be given below under a series of separate headings.

The Vitamin C Contents of Hips of British and Foreign Species of Roses.

The following tables are reprinted from the contribution of Melville and Pyke, in which the wide variation in ascorbic acid content of the hips of different species of roses is clearly marked. The distribution of the roses and the physical properties of the hips are also described from their paper.

<i>British Species :</i>	mg. per 100 g. of flesh.	% of pips in whole fruit.	mg. per 100 g. in whole fruit
<i>Section Villosae.</i> (Downy-leaved Dog Roses.)			
<i>Rosa mollis</i> var. <i>typica</i>	1490	24	1130
<i>R. mollis</i> var. <i>fallax</i>	1560	30	1090
<i>R. mollis</i> var. <i>caerulea</i>	1250	51	612
<i>R. Sherardi</i> var. <i>eminens</i>	854	27	623
<i>R. Sherardi</i> var. <i>scotica</i>	652	55	293
<i>R. tomentosa</i> var. <i>sylvestris</i>	590	32	401
<i>Section Caninae.</i> (Common Dog Roses.)			
<i>R. canina</i>	960	28	691
<i>R. dumetorum</i>	918	51	450
<i>Section Rubiginosae.</i> (Sweet-briar Roses.)			
<i>R. rubiginosa</i>	635	39	387
<i>R. agrestis</i> var. <i>Gizellii</i>	420	37	265
<i>Section Systylae.</i> (Field Roses.)			
<i>R. arvensis</i> var. <i>capreolata</i>	450	22	351
<i>Section Spinosissima.</i> (Burnet Roses.)			
<i>R. spinosissima</i>	260	25	195

The hips of *R. mollis* are the richest source of vitamin C among the British species whilst those of the Burnet Roses, readily distinguished by their dark purplish black appearance, are very poor in quality. Native forms of *R. arvensis* have later been proved to be lowest in vitamin C of all, with a mean of 80 mg. per 100 g. of flesh.

<i>Foreign Species :</i>	mg. per 100g. of flesh.	% of pips in whole fruit.
<i>R. therebintinacea</i>	1370	28
<i>R. Fedtschenkoana</i> (Wisley)	3050	34
<i>R. "</i> (Kew)	4800	45
<i>R. Moyesii</i>	1250	26
<i>R. Moyesii</i> var. <i>Fargesii</i>	1580	13
<i>R. Moyesii</i> var. <i>setipoda</i>	1600	15
<i>R. elymaitica</i>	2080	20
<i>R. cinnamomea</i>	1070	33
<i>R. saluevensis</i>	920	31
<i>R. macrophylla</i>	1990	23
<i>R. calocarpa</i>	926	29
<i>R. rubrifolia</i>	1030	37
<i>R. pomifera</i>	1020	30

Russian workers have reported the vitamin C content of *R. cinnamomea* to be as high as 4.75%,—ten times the amount of the average British hip.

Distribution of Wild Roses in Great Britain.

The British rose species are distributed unevenly throughout the country ; *R. mollis* is a common rose of the North of England and Scotland ; *R. Sherardi* occurs in England and Scotland ; *R. canina*, *R. dumetorum* and *R. arvensis* are found in England ; *R. rubiginosa* is local and scattered, whilst *R. spinosissima* occurs on sandy soils, especially round the coast.

The order of ripening begins with *R. mollis* and *R. Sherardi* about the

beginning of September, followed by the common dog-roses with *R. rubiginosa* and *R. arvensis* still later. This information, together with that in the next paragraph, is taken from Melville and Pyke's work.

Physical Properties of British Rose-Hips.

Physical tests have shown that the pectin contained in the rose-hips is of low quality from the point of view of jelly making, and if a jelly is required, apple pectin or other pectin with good jellying properties must be added to obtain a set when sugar is added.

Hips of different rose species fall roughly into two classes. In one, which includes *R. canina*, *R. dumetorum* and *R. rubiginosa*, the hot water extract is mucilaginous whilst in the other, including *R. mollis*, *R. Sherardi*, *R. tomentosa*, *R. arvensis* and *R. agrestis*, the hot water extract is only slightly mucilaginous.

The flavour of the juice obtained from different species of rose varies very considerably from one to another. In *R. canina*, *R. arvensis* and *R. dumetorum* a rich plum flavour is obtained when sugar is added to the juice. *R. tomentosa*, *R. mollis* and *R. Sherardi* have milder though pleasant flavours. *R. rubiginosa* and *R. agrestis* have milder or rather insipid flavours.

Relationship between Vitamin C Content and Ripeness of Rose-Hips.

There have been a number of confusing statements in the literature relating to the period at which the maximum development of vitamin C takes place in the rose-hip. Goldberg and Walsh (15) indicated that the vitamin C content appears to be constant whether the fruits are barely ripe or fully ripe and soft. A sample of hips collected on September 4th, 1938, at an early stage of ripening, yellow in colour and turning red, assayed 385 mg. ascorbic acid per 100 g. fresh fruit; a sample collected on September 18th in a hard ripe, scarlet red condition assayed 364 mg. per 100 g.

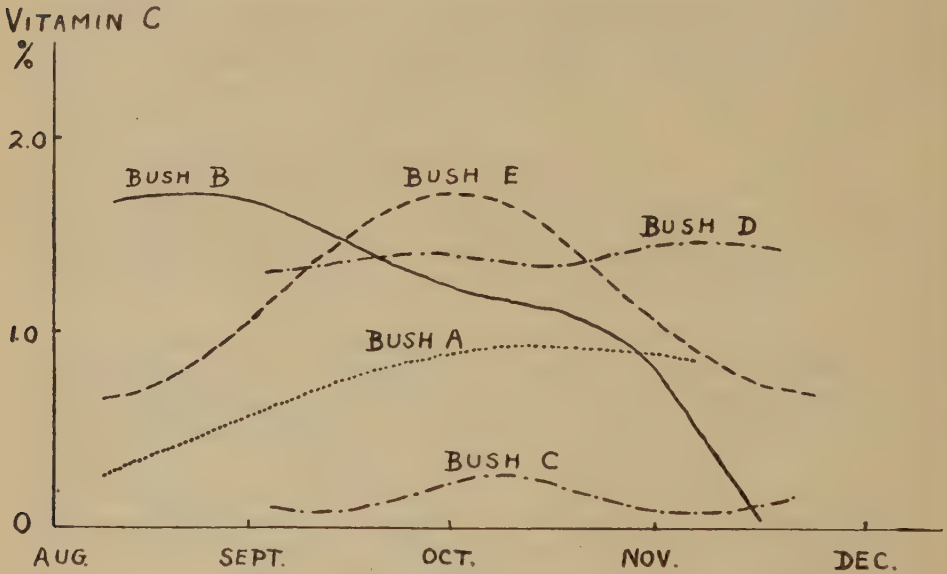
Andross (16) compared the ascorbic acid values of under-ripe, ripe and over-ripe rose-hips gathered between September and December. In each case there was a gradual reduction of ascorbic acid, commencing with the highest figure in late September and concluding with the lowest in late December. The author quotes a table to illustrate this gradual loss of ascorbic acid and this is reproduced below:

TABLE I.
VITAMIN C IN RAW HIPs AND IN PUREE FOR DIFFERENT MONTHS.

Date.	Under-ripe mg. per 100 g.		Ripe mg. per 100 g.		Over-ripe mg. per 100 g.	
	Fruit.	Puree.	Fruit.	Puree.	Fruit.	Puree.
Sept. 25th ..	595-623	255-323	576-590	276-280	—	—
Oct. 10th ..	585-600	280-295	564-578	252-276	—	—
Oct. 25th ..	550-570	276-283	532-570	263-280	500-550	215-230
Nov. 10th ..	523-546	252-273	520-541	250-263	458-502	202-218
Nov. 25th ..	481-525	230-248	480-510	230-250	410-436	191-203
Dec. 10th ..	431-467	203-230	410-465	190-230	410-432	180-187
Dec. 25th ..	—	—	405-418	190-210	370-408	161-180

It was also stated that on comparing the ascorbic acid contents of large juicy fruits with those of medium sized fruits, lower figures* were obtained from the former than from the latter, viz., 230–270 mg. per 100 g. and 300–350 mg. per 100 g., respectively.

Hammar and Schröderheim (4) examined the hips from a number of rose bushes at intervals during the autumn months near Stockholm and discovered a striking variation in the production of ascorbic acid from one bush to another. The following graph is taken from their paper:



Variation of the vitamin C contents of the hips of rose bushes with time.

The ascorbic acid content of rose-hips from one bush displays a gradual climb from August to October (Bush A) and in another case a diminution during the same period (Bush B). In other cases the ascorbic acid content remains at a constant level for several months (Bushes C and D) whilst in yet another it climbs up to a certain point and then falls again (Bush E). The authors do not make it clear whether these bushes represent different species or not, but it is assumed that they do, since at a later stage in the paper they state that the maximum ascorbic acid content is reached in different kinds of rose-hips at different times.

The Drying and Storage of Rose-Hips.

According to the authors quoted above a considerable amount of rose-hips are sold in Sweden in dried or powdered form for the purpose of making hip soups and teas. The quality of the commercially dried samples, however, is very variable and may contain as little as 75 mg. of ascorbic acid per 100 g. (0.075%) or as high as 0.75–1.0%, according to the manner in which the fruit is treated.

* These figures represent the ascorbic acid contents of purees prepared from the fruits.

On the average, the commercial drying of rose-hips in Sweden resulted in a loss of 60–70% ascorbic acid caused by too rapid dehydration in the presence of air by means of ovens and in addition, in the case of powdered hips, by oxidation during milling or grinding. The writers claim that by using a special process of drying rose-hips, details of which are not published it is possible to prepare samples containing 1.0–1.5% ascorbic acid and from average hips a product containing not less than 0.5%, although powdered hips would retain less.

It is also claimed that after drying the hips the remaining ascorbic acid is fairly stable. Experiments showed that the ascorbic acid remained unchanged between the autumn and spring, but prolonged storage under the influence of damp adversely affected the stability of the vitamin.

Goldberg and Walsh (15) analysed a sample of soft, black, kiln-dried hips of German origin and found 64 mg. ascorbic acid per 100 g. (based on calculated weight of fresh fruit). Miscellaneous samples of English rose-hips collected in September were dried at 40°C and 60°C. The higher temperature resulted in a loss of 50% and the lower in a loss of 80–90% ascorbic acid. Actual analyses were 186 and 54 mg. ascorbic acid per 100 g. (based on original weight of fruit).

Andross (16) dried rose-hips according to the method advocated by Loewenfeld (18) and estimated the vitamin C content after storage for 6 months. The hips were split and dried over water in a moderate oven, and were then rubbed out and the fleshy parts stored in boxes. It was found that the average retention of vitamin C was about 50 per cent.

Rose-Hip Jam and Puree.

Andross prepared rose-hip puree by stewing 2 lb. of hips, freed from calyces, for twenty minutes with 2 pints of water, followed by rubbing through a hair sieve. The puree so obtained was canned and bottled. Figures for the vitamin C contents of purees prepared from hips collected at different stages of ripeness and at different times are included in Table I. The highest vitamin content is found in the puree which was prepared from under-ripe hips gathered in late September.

Table II is cited to demonstrate the stability of ascorbic acid in canned puree during storage:

TABLE II.
STABILITY OF ASCORBIC ACID IN CANNED ROSE-HIP PUREE.

Date.					mg. ascorbic acid per 100g.
1940	October 25th	..	..	..	428
	November 25th	..	..	..	371
	December 25th	..	..	..	376
1941	January 25th	..	..	..	358
	February 25th	..	..	..	361
	March 25th ..	..	..	..	342

Rose-hip jam was prepared by the same author by boiling two pints of puree with 1½ lb. of sugar to 50 per cent sugar content. Apple pectin was

added to obtain a set. Little destruction of vitamin C was caused and on prolonged storage the jam retained 130–231 mg. per 100 g. The satisfactory stability of ascorbic acid in rose-hip jam is confirmed by Besaric and Rikovski (3) already referred to above.

It is of interest to record that Goldberg has recently given warning of the possible danger of sharply pointed hairs in jams prepared from rose-hips (*News Chronicle*, August 13th, 1941). These hairs occur on the inside of the fruit and envelop the seeds. Melville and Pyke assert that if the fruits are boiled with water to produce a pulp and this is rubbed through a hair sieve, a large proportion of the hairs pass through. The effect of these hairs when such a preparation is eaten is to cause a slight irritation at the back of the throat and to the bowels resulting in some looseness. The writers quote Barton and Castle (*British Flora Medica*) who state that the hairs have a similar action to Cowhage. The hairs from the fruit pods of this plant (*Mucuna Pruriens*) are used as vermifuge on account of their irritant action.

Rose-Hip Soup and Tea.

Much importance is attached in Sweden to the antiscorbutic properties of rose-hip soup and tea prepared from dried fruits. Thus, Salén and Ollén-Löfgren (19) in April 1938, in an address to the Schwedischen Verein für Innere Medizin urged that increased use be made of rose-hip soups and jam in hospital diets. Hammar (in collaboration with Schröderheim (4) working at the Zentrallaboratorium der Stockholmer Brauereien) examined and improved the method of preparing rose-hip dishes at the Norrtull Krankenhaus where children have been taking rose-hip soups, etc., for some considerable time.

Rose-hip soup is stated to be the most universal dish containing rose-hips in Sweden. It is usually prepared by cooking whole hips for 1–2 hours after which it is strained, thickened with potato meal, again heated up and finally sweetened to taste. Such products have usually been found on analysis to contain low values of 5–10 mg. ascorbic acid per cent., half-a-pint of which would contain about half the daily human requirement. However, by using high value hips (dried by special method) the writers demonstrated that, with precautions, it was possible to prepare a soup with 1 part of dried hips to 10 parts of water containing 100–200 mg. vitamin C per cent. (The poor quality of certain brands of commercially dried hips was mentioned in an earlier paragraph).

Rose-hip tea is prepared on similar lines to that of the soup, except that no thickening materials are added. It is sweetened to taste and may be taken hot or cold.

In conclusion, Andross (16) recommended rose-hip soup made with a lentil stock base as an excellent substitute for tomato soup.

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PRESERVING FRUIT WITH THE "CAMPDEN FRUIT PRESERVING TABLETS."

PROGRESS REPORT.

By ALICE CRANG.

Introduction.

During the early part of the summer of 1940, a very large number of enquiries were received for the "Campden Preserving Solution." This is a solution of sulphurous acid of known strength which has been supplied for preserving fruit on a domestic scale. The method of use is to place the sound, uncooked fruit in a jar, cover with a solution of sulphurous acid of known strength and to close with an airtight seal. The sulphur dioxide is removed by boiling the fruit just before use. The method had been carefully worked out by Barker and Grove (1) and was found to be very suitable for preserving plums. The demand for this solution was never large in peace time, but, owing to the restrictions on sugar supplies, the usefulness of this method of storing fruit was soon realized under war conditions, particularly in a season when there was a glut of plums.

It became apparent in 1940 that it would be impossible to meet the demand for this preparation, as hitherto, from this Department, and consequently it was decided to supply the necessary information regarding the process to manufacturing chemists who could distribute the preservative through the usual trade channels. It was realized that practical difficulties would be encountered by chemists in ensuring the correct strength of sulphur dioxide in the sulphurous acid solution for the length of time during which it might be exposed for sale, so experiments were started to discover alternative sources of sulphur dioxide which would be more stable.

Potassium metabisulphite was first tested as the source of sulphur dioxide, as this substance had been used with success for a number of years in preserving fruit syrups and other fruit products. It had also been tested previously as a preservative for plums by Charley (2). Towards the end of 1940 there was a shortage of potash in the country so that sodium metabisulphite was examined as a possible form in which to add the preservative.

Owing to the short time available for marketing the preservative, if this were to be of any use in helping to save the plum crop in 1940, it was only possible to test it with a very limited amount of fruit before the instructions for its use had to be printed. The method has proved to be extremely popular during the two fruit seasons in which it has been available, but there have been failures, many of which can be avoided by the issuing of fuller instructions with the tablets. The main problems encountered in using the method have been examined and the results obtained are summarised below.

Strength of Preservative.

The concentration of sulphur dioxide which had been found to be most effective in preserving fruit by the "Cold Process" (1) was 1000 p.p.m. SO_2 in the solution. The recommendation previously given with the "Campden Solution" as supplied for domestic preservation by this Department, was that

a bottle of sulphurous acid diluted to 1 gallon with water (giving a solution of 1000 p.p.m.) should be used to cover 14 lb. of fruit.

When the tablets of potassium metabisulphite were prepared the concentration recommended was that each tablet should contain the equivalent of 4 grains of sulphur dioxide, to be diluted in $\frac{1}{2}$ pint water, giving a concentration of approximately 913 parts per million. The recommendations given also stated that 1 tablet would usually be sufficient for preserving 1 lb. fruit, but that the fruit in the jar must be covered by the solution. This concentration is therefore rather less than that previously recommended because in practice it is found that many fruits need a higher proportion of liquid to fruit, particularly if the fruit is stored in small containers; and too high a concentration of sulphur dioxide is thus avoided. The average dilution of the sodium metabisulphite tablets as received, when diluted to $\frac{1}{2}$ pint of water, gave a concentration of 950 p.p.m. sulphur dioxide.

Use of Sodium or Potassium Metabisulphite.

There appears generally to be little difference in the keeping quality of the fruits when an equivalent quantity of sulphurous acid, potassium metabisulphite or sodium metabisulphite is used as the source of sulphur dioxide. The only case in which sulphurous acid is definitely the most suitable source of preservative is for the fruits which contain insufficient acid to liberate the sulphur dioxide from the salts, such as pears or sweet cherries.

No difference in flavour could be detected by most tasters in the cooked fruit, due to the different preservatives.

Suitability of Fruits for Preserving by Sodium or Potassium Metabisulphite.

KIND.	RESULT.
Apples (culinary)	Apples when peeled, cored and quartered, then treated as other uncooked fruit, are satisfactory.
Blackberries (cultivated)	Keeping quality variable. Acid fruits generally satisfactory. Fermentation with others after short storage.
,, (wild)	Most ferment after comparatively short time of storage. This may be due to lower acid content in these fruits, but the addition of acid with the preservative appeared to be no advantage.
Blackcurrants ..	Satisfactory for storage; preservative rather difficult to remove by boiling before using the fruit.
Cherries (sweet)	Most samples ferment after a short period of storage, due probably to insufficient acid in the fruit to liberate the sulphur dioxide.
,, (Morella)	Satisfactory.
Damsons ..	Satisfactory.
Elderberries ..	Results variable, some fermenting after a short storage.
Gooseberries ..	Satisfactory for storage. Preservative has a toughening effect on the skins.
Loganberries ..	Satisfactory—colour well retained.

Pears	Peeled, sliced and treated as for apples; unsatisfactory. Fermentation after short periods of storage—probably due to insufficient acid present to liberate the sulphur dioxide.
Plums	Satisfactory.
Raspberries	Satisfactory.
Rhubarb	Satisfactory for storage. Needs rather longer cooking than usual to remove preservative before use.
Strawberries	Firm sound fruit store satisfactorily, but berries will not keep if too soft or overripe. Some permanent loss of colour.
Tomatoes	A large proportion of tomatoes fermented or mould grew in the jars after short periods of storage. Skinned or quartered tomatoes fermented more quickly than whole ones.

From the results above it appears that most acid fruits store satisfactorily by this method, but it is not suitable for the less acid fruits. Vegetables containing negligible amounts of acid are quite unsuited to this type of preservation, and those tested fermented even if sulphurous acid was used. The fruits used must be sound and not overripe.

Method of Sealing Jars.

As the quantities of sulphur dioxide used to preserve fruit in this way are considerably less than that used in commercially sulphited fruits, an essential part of the process is that the jars should be rendered airtight before storage.

Corks to fit the jars, covered with a layer of fat or wax, had been advocated previously, but there is considerable difficulty in obtaining large corks for many of the jars used in the home. Unprotected metal tops would be unsuitable owing to the corrosive action of the sulphur dioxide on the metal.

Various other methods of covering the jars were tested, first using sulphur dioxide solution itself, and any that gave fairly reliable results were later tested on the preserved fruit.

TRIALS WITH SO₂ SOLUTION.

Type of Cover.	Method of Sealing.	SO ₂ Strength of Solution.	
		Initial.	After 1 month storage at 86°F.
Moisture proof Cellophane	1 layer, damped and tied on as for jam.	1120	242 p.p.m.
	2 layers " " "	1120	242 p.p.m.
Brown Paper	2 layers pasted together and on to jar with flour and water paste.	1120	0 p.p.m.
	3 layers as above.	1120	40 p.p.m.
	Waxed paper first then three layers of brown paper as above.	1120	40 p.p.m.

TRIALS WITH SO_2 SOLUTION—*contd.*

1 lb. Kilner Preserving Jar (as control)	Rubber band between glass lid and jar held in place with metal screwband.	1120	889 p.p.m.
"Three Point Pack" (manufactured for the purpose)	Waxed cardboard disc put on jam jar, with cardboard cover having adhesive layer to adhere to rim of jar.	1120	403 p.p.m.
Porosan Synthetic Skin ..	Skin tied on with string. No heating	1216	242 p.p.m.
	Skin dipped 20 secs. in boiling water, tied on hot.	1216	242 p.p.m.
"Backing Cloth"	1 layer of material warmed to render it adhesive tied on jar while hot.	1216	0 p.p.m.
	2 layers applied as above.	1216	0 p.p.m.
1 lb. Kilner Preserving Jar (as control)	Rubber band between glass lid and jar, held in place by screwband.	1216	890 p.p.m.

These figures show a considerable loss of sulphur dioxide in each case. Part of this loss is accounted for by the increased temperature during storage, causing a positive pressure in the jar, so that gas escapes between the jar and the lid.

THE FOLLOWING COMPARATIVE TESTS ON PRESERVED FRUIT SHOW FURTHER THE EFFECTIVENESS OF THE METHOD OF SEALING AFTER STORAGE.
THE CONTROLS USED IN EACH CASE WERE GLASS KILNER TYPE OF PRESERVING JARS.

TRIALS WITH FRUITS.

Cover.	Fruit Used.	Original SO ₂ Content. p.p.m.	Period of Storage.	Treated Samples.		Controls.	
				SO ₂ Content. p.p.m.	Appearance.	SO ₂ Content p.p.m.	Appearance.
Cellophane (moisture proof). 1 layer .. 2 layers ..	Rhubarb ..	453	1 month at 77°F.	286	Satisfactory	436	Satisfactory
	" ..	453	"	313	"	436	"
Cloth dipped in melted paraffin wax, tied on on with string.	Tomatoes, quarters	366	5 months	—	Thick mould 2 samples	234	"
	Tomatoes, whole	366	5 "	—	Thick mould	333	"
	Tomatoes, pulped	366	5 "	341	Satisfactory	335	"
	Plums ..	350	5 "	167	"	—	"
	Apples ..	430	5 "	250 26	Fermenting	166 51	Fermenting
	Tomatoes ..	366	5 "	164	Satisfactory	234	Satisfactory
Waxed Cork	Damsons ..	350	3 1/2 "	—	Satisfactory	—	"
Metal cover waxed inside, kept in place with spring clip	Plums ..	350	5 "	173	"	—	"
	Apples ..	350	4 "	—	"	—	"
Oiled silk smeared with vaseline on inner side	Blackcurrants ..	205	3 "	—	(a) " (b) " (c) "	—	"
	Apples ..	350	4 "	—	(a) Thick mould (b) " (c) "	166	"
Paraffin wax, melted, poured over surface and neck of jar	Gooseberries ..	384	7 weeks	74	Doubtful	156	"
	Plums ..	350	5 months	91	"	—	"
	Tomatoes ..	366	5 "	—	(a) Mould (b) "	(a) 234 (b) 333	"
	Rhubarb ..	453	1 month at 77°F.	298	Satisfactory	436	Satisfactory
Porous Synthetic Skin (Unheated)	Rhubarb ..	453	"	(a) 277 (b) 286	"	436	"
Porous dipped in boiling water 20 secs put on hot	Damsons ..	350	4 months	Liquid 118 Fruit 141	"	Liquid 186 Fruit 364	"
	Black Currants ..	205	3 months	—	(a) " (b) " (c) Mould	—	"
" Three Point Pack "	Red Currants ..	205	"	—	(a) Satisfactory, but 1" shrinkage	—	"

Several of the methods of sealing jars appear fairly satisfactory, though some loss of sulphur dioxide obviously occurs. A surprising factor is the small amount of sulphur dioxide which is present in many cases and which appears effective in preserving the fruit.

Paraffin wax alone, or mixtures of paraffin wax and liquid medicinal paraffin also tested, are not effective seals. Fruit preserving jars, either with glass lids or with metal lids protected from the sulphur dioxide by a layer of wax inside, are the best seals tested.

Methods of Cooking the Fruit.

Various methods of cooking the fruit were tried to see which was the most effective way of removing the preservative and at the same time retaining the best fruit flavour.

In all cases the fruit needs cooking in an open pan before it is used as a dessert or in puddings.

The soluble constituents of the fruit are found to be nearly evenly distributed in the liquid and fruit after storage; consequently the liquid should be used in all cases, instead of water, for cooking the fruit, otherwise serious loss of flavour will be noticeable.

It is important that the fruit be boiled before any sugar is added, otherwise the sulphur dioxide is not so readily removed. This was proved in the following test :—

	RESULT.
(a) 12 oz. damsons + 1 oz. water brought to the boil in an open pan, boiled 10 min. then $1\frac{1}{2}$ oz. sugar added and boiled further 5 min.	SO ₂ content of cooked fruit (excluding stone) 51 p.p.m.
(b) 12 oz. damsons + 1 oz. water + $1\frac{1}{2}$ oz. sugar brought to the boil in similar pan, boiled 15 min.	SO ₂ content of cooked fruit (excluding stone) 77 p.p.m.

In certain cases, difficulty was found in removing the sulphur dioxide without prolonged boiling, even without the addition of sugar. The following methods were compared :—

	RESULT.
(c) 4 oz. whole plums + 5 oz. liquid brought to the boil in 3 mins. boiled for 10 mins.	SO ₂ content of cooked fruit (stone free) 120 p.p.m.
(d) 4 oz. similar plums halved and stones removed before cooking. Amount of liquid and time of cooking similar to c.	72 p.p.m.
(e) 4 oz. similar plums and liquid cooked for same time as c, with addition of $\frac{1}{2}$ oz. lemon juice.	101 p.p.m.

From these figures, the advantage of stoning the fruit before cooking is apparent whenever difficulty is found in removing the preservative. The addition of acid is not very effective.

In general, boiling the fruit for 10 minutes before adding any sugar and

then boiling a further 10 minutes ensures the removal of most of the sulphur dioxide. The residual sulphur dioxide found varied from 8 to 38 p.p.m.

The samples of tomatoes which were stored without fermentation or mould growth occurring, were boiled; boiled and sieved; fried and cooked in a casserole. In each case the flavour was considered poor and rather bitter and the skins were tough. Tomatoes are not therefore recommended for preserving by this method.

Jam could be made quite satisfactorily from the preserved fruit. Provided the liquid was used in the proportion present in the preserved fruit, 1 lb. of drained fruit was found to be a satisfactory amount to replace 1 lb. of fresh fruit in the jam recipe. The fruit and liquid should of course be boiled before any sugar is added. Deterioration of the setting power of the preserved fruit is being investigated.

Summary.

1. The method of preserving fruit with potassium or sodium metabisulphite tablets, generally sold by chemists under the name "Campden Fruit Preserving Tablets," has proved satisfactory with most fruits, though it is not a suitable method to use with the less acid fruits such as sweet cherries or pears. Wild blackberries and tomatoes also generally give unsatisfactory results. The effect of these two substances appears to be similar when used in the same concentration.

2. Methods of covering the jars in the home have been examined, and though the fruit preserving jars, or earthenware jars with corks waxed over the top, are generally the most reliable, several other methods of covering the jars have appeared to be fairly satisfactory.

3. The fruits should generally be boiled for 10 minutes in an open pan before the addition of any sugar. Further boiling should then be continued for at least another 10 minutes. The preservative has a toughening effect on the skins of certain fruits.

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NOTES ON DOMESTIC FRUIT AND VEGETABLE PRESERVATION.

By ALICE CRANG.

I. Factors Affecting the Keeping Quality of Jam.

(a) *The Type of Cover and Prevalence of Mould Growth.*

The effect of the type of cover used on the keeping quality of the jam is shown in the following tests. In each case the jams used were somewhat low in sugar content and of weak consistency and were stored together in a warm, damp atmosphere, to encourage the development of mould growth. In all cases waxed paper tissues were placed over the surface of the jam as soon as it was poured into the jars.

Type of Cover.	Satisfactory. No. of Samples %		Slight Mould. No. of Samples %		Mould. No. of Samples %	
Cellophane	17	85%	2	10%	1	5%
Parchment	26	81%	5	16%	1	3%
Parchment and waxed card-board disc	8	36%	2	9%	12	55%
Metal cover lined with card-board disc	3	25%	2	17%	7	58%
Gummed paper	7	58%	3	25%	2	17%
Tissue paper and milk	0	—	6	50%	6	50%
Parchment and waxed card-board with hole in centre ..	3	50%	0	—	3	50%

Cellophane covers were the most satisfactory as regards freedom from mould growth, but shrinkage of the jam occurred more readily in jars covered this way than with other covers.

Wasps also readily attack any jams covered with cellophane.

(b) *The Effect of Covering the Jam Hot or Cold.*

In these tests, a waxed paper disc was put on the jam immediately it was poured into the jar, and half the jars were covered at once and the other half when cold. Different types of covers were used, but they were comparative for each batch of jam. The jams were again stored in a damp atmosphere likely to cause mould growth.

	Jam Covered Hot.	Jam Covered Cold.
Satisfactory	29 (54%)	19 (35%)
Slight Mould	18 (33%)	9 (17%)
Mould	7 (13%)	26 (48%)

A disadvantage in covering the jam while hot was found to be that if the jars were well filled, there was very little space between the top of the jam and the cover, so that the latter was easily stained with the jam if the jars were tilted before the jam had set.

(c) *Shrinkage of Jam using Cellophane and Waxed Paper Tissues.*

A comparison was made of the amounts of evaporation occurring from jam during storage when cellophane or waxed paper tissues were used on the jam surface.

1 lb. jam jars were filled to the brim with boiling jam and tissues fitting the surface of the jam were at once pressed on. The tissues used were of ordinary cellophane, as supplied with cellophane covers, moisture-proof cellophane and waxed paper, as normally recommended. In each case the jars were covered with ordinary cellophane covers and stored together at room temperatures for 4 months.

	Ordinary Cellophane.	Moistureproof Cellophane.	Waxed Paper.
Shrinkage of jam in the jar after 4 months' storage.	(1) 45 ml. (2) 47 ml. (3) 47 ml. (4) 46 ml.	(1) 33 ml. (2) 34 ml. (3) 34 ml. (4) 33 ml.	(1) 28 ml. (2) 32 ml. (3) 32 ml. (4) 32 ml.
Average	46.1 ml.	33.5 ml.	31.1 ml.

Shrinkage would largely be accounted for by the natural shrinkage of the jam which occurs on cooling, but this would be the same in each case. The difference between the results would be due to the evaporation of moisture occurring more readily with ordinary cellophane than with moisture-proof cellophane or waxed tissues. In no case was there any sign of mould growth.

(d) *Use of Preservatives painted on Waxed Tissues to prevent Mould Growth on Jam.*

The effect of various preservative solutions in preventing the occurrence of mould growth on jam was examined. The jams and jellies used were of weaker consistency and of lower soluble solids content than are recommended for prolonged storage. In each case the boiling jam or jelly was poured into the jar, waxed paper tissues at once pressed on and the preservative solutions painted over the upper surface of the tissue. Half the samples were then inoculated by scattering a few mould spores on the tissues of the hot jam before the covers were put on.

SERIES I.		RESULTS AFTER STORAGE.			
Solution painted on Upper Surface of Waxed Tissue.		No. of Samples.	No Mould.	Slight Mould.	Mould.
Methylated spirit		22	45%	32%	23%
1% solution of salicylic acid in ethyl alcohol ..		14	86%	14%	0%
Glycerine		9	22%	45%	33%
Untreated		16	31%	25%	44%
SERIES II.					
2% solution of sodium salicylate in isopropyl alcohol		15	87%	13%	0%
2% solution of sodium benzoate in isopropyl alcohol and water		15	73%	27%	0%
2% solution of salicylic acid in ethyl alcohol ..		5	80%	0%	20%
Untreated		9	22%	0%	77%

Other experiments also clearly show the great benefit of dilute solutions of these preservatives in alcohol in retarding mould growth on jams. The preservatives are not at present legally allowed, for fear of contaminating the jam, but it should be noted that the preservatives are only painted over the upper surface of the tissue covering the jam, and that this is invariably removed when the jam is opened.

Summary of points which help in prevention of spoilage of jam :—

- (1) The jam should be well set and contain *at least* 60% of added sugar. This amount, together with the natural sugar in the fruit, should make a jam of sufficiently high sugar content to prevent fermentation and retard mould growth.
- (2) Clean warm jars should be used and should be filled to the brim with hot jam and covered at once with a waxed tissue pressed evenly over the surface without air bubbles between the jam surface and tissue.
- (3) The type of cover used affects the occurrence of mould. If metal or waxed cardboard is used, these should be well dried in an oven before using.
- (4) The jam is better covered at once, but this is difficult to do in practice. Jams left till cold before covering should have a clean cloth or clean paper put over the jars until they are covered.
- (5) Certain preservative solutions in alcohol, when painted on the top of the waxed tissue, have a marked effect in preventing mould growth. These are not, however, officially allowed for use on jam which is for sale.

II. Relative Pectin and Acid Contents in Citrus Fruits.

The following figures indicate the relative importance of the parts of citrus fruits from the point of view of their pectin and acid contents, which

is of importance in marmalade making. As only one analysis is given in each case, the figures only serve as a comparison of the particular fruits used.

Fruit.	Layer of Fruit.	Weight (Average per Fruit).	Pectin % (as Calcium Pectate).	Acid % (as Citric Acid).
Grapefruit (Jamaican) ..	Flavedo, or outer peel ..	24.8 g.	0.37	0.51
	Albedo or pith ..	26.5 g.	3.68	0.28
	Pulp (without pips) ..	221.6 g.	0.62	1.02
	Pips	7.5 g.	3.27	0.18
Lemon (Spanish) ..	Flavedo	16.9 g.	1.12	0.62
	Albedo	6.8 g.	4.51	0.64
	Pulp	16.8 g.	0.93	6.16
	Pips	1.8 g.	2.31	1.45
Orange (Seville) ..	Flavedo	12.5 g.	0.15	0.42
	Albedo	43.0 g.	1.33	0.52
	Pulp	49.0 g.	1.04	2.69
	Pips	7.0 g.	3.12	1.06
Orange Sweet, Seedless. (S. African) ..	Flavedo	15.7 g.	1.11	0.28
	Albedo	16.2 g.	2.93	0.17
	Pulp	30.6 g.	0.46	1.41

DISTRIBUTION OF THE PECTIN AND ACID IN THE PARTS OF THE FRUIT, EXPRESSED AS %
OF THESE SUBSTANCES IN THE WHOLE FRUIT.

Fruit.	Layer of Fruit.	Weight.	Pectin.	Acid.
Grapefruit ..	Flavedo	8.8%	3.4%	5.1%
	Albedo	9.4%	36.2%	3.0%
	Pulp (without pips) ..	79.1%	51.2%	91.4%
	Pips	2.7%	9.2%	0.5%
Lemon	Flavedo	19.6%	17.1%	2.7%
	Albedo	7.9%	27.9%	1.1%
	Pulp	70.4%	51.2%	95.5%
	Pips	2.1%	3.8%	0.7%
Orange (Seville) ..	Flavedo	11.2%	12.6%	3.1%
	Albedo	38.6%	38.5%	13.4%
	Pulp	43.9%	34.2%	79.0%
	Pips	6.3%	14.7%	4.5%
Orange Sweet, Seedless	Flavedo	25.1%	20.0%	8.7%
	Albedo	25.9%	60.1%	5.5%
	Pulp	49.0%	17.9%	85.8%

PECTIN AND ACID CONTENT OF THE WHOLE FRUIT.

Fruit.	Pectin (as Calcium Pectate).	Acid (as Citric Acid).
Grapefruit	0.96%	0.87%
Lemon	1.28%	4.57%
Orange (Seville)	1.18%	1.50%
Orange (Sweet, Seedless)	1.26%	0.81%

These figures show the high pectin content of the albedo or pith and of the pips if present. This is of importance, as many people tend to discard most of the pith and pips in marmalade making, without first extracting the pectin from them. The pulp contains most of the acid in each of the fruits tested.

III. Jam Recipes from Wild Fruits and Rhubarb.

The scarcity of fruit for jam-making in 1941 encouraged the use of any edible wild fruits and rhubarb for domestic preserves. Many of these fruits contain insufficient acid or have pectin of poor setting quality, so do not make satisfactory products when used alone and lemon juice is normally added to overcome these deficiencies.

As no lemons were available in 1941, various recipes were tested to see how far the wild fruits and rhubarb could be utilized in making good quality preserves. During the fruit season over 90 different jams or jelly recipes have been tested. Whereas many of these were not considered to be satisfactory, others, such as rhubarb and loganberry or elderberry and apple mixtures, made quite satisfactory products. Many of the jams or jellies were tested particularly for their suitability for use in Fruit Preserving Centres and recipes of satisfactory products are being printed for use of these Centres in 1942.

IV. Rose Hip Products.

The shortage of fruit in 1941 aroused renewed interest in rose hips, especially as a source of ascorbic acid, and the possibilities of using them in domestic preserves were examined. Three factors were taken into consideration in making the domestic preserves. Rose hips contain considerable quantities of pectin, but this is of very poor setting quality; the seeds in the hip are surrounded with barbed hairs which might act as a dangerous irritant unless they were removed; and the preserves should be made so that as much of the ascorbic acid as possible should be retained.

Rose Hip Jams.

Two methods of preparing the jam were examined:—

(1) The hips were halved, seeds and hairs carefully removed, the flesh cooked with water until soft, sugar added and the jam boiled to the usual sugar concentration.

Results: The jam set but was "sticky."

Ascorbic acid content of the jam when first made was 168mg/100g

Amount of ascorbic acid extracted from the hips—65%.

This preserve would only be suitable for preparing in very small quantities and the preparation is very lengthy and tedious.

(2) The rose hips were simmered with water until soft, the pulp rubbed through a hair sieve, sugar added to the pulp and boiled to the usual sugar concentration.

Results: The jam had a very weak consistency.

Ascorbic acid content when first made—137mg/100 g.

Amount of ascorbic acid extracted from the hips—17%.

This preserve had a very irritating effect on the throat when eaten, and microscopical examination confirmed the presence of numerous sharp hairs which had not been removed in sieving.

Rose Hip Jelly.

Various attempts were made to obtain a satisfactory jelly from the rose hips, but none of these were really satisfactory, even when acid was added to ensure the optimum conditions for obtaining a gel. In some cases a weak set was obtained when the jelly was first made, but this broke down after a very short period of storage.

Rose Hip Syrup.

The preparation of the syrup was based on the methods found to be most satisfactory by the Fruit Products Section when extracting rose hips for commercial syrup production.

The hips were minced or crushed, extracted at once in boiling water, strained, the residue extracted a second time and the combined filtrates concentrated, sugar added and the syrup bottled and sterilized.

Results : Ascorbic acid content of the rose hips used 380 mg/100 g.
Ascorbic acid content of the rose hips syrup 165 mg/100 g.
Amount of ascorbic acid extracted 54.3%.

This was considered to be the most satisfactory method of utilizing rose hips for domestic preserves and the amount of ascorbic acid extracted in this syrup was considerably higher than that in the other domestic rose hip syrup recipe recommended at that time by the Ministry of Food, in which the ascorbic acid extracted was 33%.

V. Fruit and Vegetable Drying.

Fruit.

Different varieties of plums were dried under various domestic conditions. Slow drying at temperatures not exceeding 140° F. generally proved to be the most satisfactory method. Preliminary blanching in lye or in boiling water increased the rate of drying, but the products were not so satisfactory. In no case was the product considered to be up to the standard of commercially dried prunes.

Vegetables.

The most satisfactory temperature for drying vegetables was also about 140° F. In most cases the vegetables needed blanching in boiling water before drying, though spinach dried more readily without this treatment.

The freshly dried vegetables were quite satisfactory in several cases but they deteriorated very much in flavour after three or four months storage in paper bags, which were kept in the dark at room temperature. The ascorbic acid content of the dried material showed a similar deterioration under these conditions. An example is provided by the results obtained on perpetual spinach :—

	Ascorbic Acid.
Fresh spinach	27 mg/100 g.
Spinach dried to 1/10th original weight, stored 1 day.	
Unblanched	142 mg/100 g.
Blanched	235 mg/100 g.
„ Stored 8 months. Unblanched	2.0 mg/100 g.
Blanched	1.2 mg/100 g.

While dried vegetables are very useful for use in an emergency, the results obtained so far are not sufficiently encouraging to recommend domestic drying on a large scale.

CONCENTRATED SWEDE JUICE AS A SOURCE OF VITAMIN C.

By D. P. HOPKINS.

The paper on carrot treacle (p. 102) will show the ease with which clarified juice can be obtained from a root vegetable. It has therefore seemed worth while to examine the swede, a root vegetable that contains the water-soluble vitamin C, which should be largely expressed in the juice; since the concentrated juices might well prove to be valuable sources of ascorbic acid.

Swede Juice.

A 13 lb. sample of farm-grown swedes was milled in the Long Ashton apple-grater type mill. It was necessary to cut the swedes in half to allow them to enter the mill smoothly, but, apart from this simple operation, milling to a finely disintegrated and moist mash was accomplished with ease. When pressed in a laboratory hand-press, juice flowed freely from the milled material. The volume of juice obtained corresponded with a yield of 130 gallons per ton, that is, about the same yield as is given with milled carrots in a hand-press; no doubt on the large scale using a hydraulic press 150 gallons to the ton of swedes would be given as is the case with carrots.

The raw juice was cloudy and heavily charged with colloidal suspensions. It had a specific gravity of 1.033 and a pH of 6.64.

Heat treatment produced an even sharper clarification than is the case with carrot juice. At 70°C. and over, the colloidal matter precipitated as a bulky deposit and by subsequent filtration through muslin a clear amber juice was obtained.

The vitamin C values were as follows: before clarification, 17.2 mg. per 100 c.c.; after clarification, 16.9 mg. per 100 c.c.

There would seem to be no pectin problem with swede juice, the precipitate formed by adding an excess of alcohol being stringy and granular in type rather than gelatinous.

Swede Juice Concentrate.

A quantity of this juice was evaporated in vacuo until a strongly concentrated product was obtained. On cooling, this had the consistency of a thick treacle, was light brown in colour and only slightly cloudy. In appearance it was rather more attractive than samples of carrot treacle produced at Long Ashton, but this was probably due to the better degree of initial clarification. The gravity of the treacle was approximately 1.410. From the point of view of sugar content this treacle was just as sweet as similar treacles made from carrot juice or neutralised apple juices.

From the gravity changes the degree of concentration would seem to have been 12.4 : 1. The vitamin C value of the treacle was 180.5 mg. per 100 c.c., that is 10.7 times the original value of the juice. There would seem, therefore, to have been a loss of approximately 1/7th of the total ascorbic acid present during the vacuum evaporation.

A small portion of the treacle was left in an open vessel for eight weeks. Despite this long and free access to air with its accompanying mould spores, yeasts, etc., the treacle remained sound. After this period re-evaluation of

the vitamin C content showed a figure of 120 mg. per 100 c.c. This retention of 66% of ascorbic acid after such drastic exposure indicates a satisfactory stability.

Another portion of the juice was evaporated to a concentrate by ordinary open boiling. The concentrate had a gravity of 1.320. But although the soluble solids had been concentrated just under 10 times the vitamin C was only 7 times greater than in the juice, so that a 25% loss of total ascorbic acid had occurred. Vacuum evaporation thus seems to be essential.

Aroma and flavour. After twenty-four hours standing, raw or clarified swede juice develops a strong smell of the "cabbage-water" type, possibly due to certain sulphur compounds present in minute quantities. This smell seems to be associated with a sharp back-taste not unlike pepper or mustard. Although these features are largely removed in the vacuum evaporation they still persist to a slight extent in the final treacle. It is felt that the use of activated charcoal during the heat treatment or of some other common type of impurity-remover would overcome this objection, but further tests on a larger scale are necessary before this point can be settled. But, even should progress be impossible in this direction, it should be easy to neutralise the flavour by blending the swede treacle with other vitamin C products that have stronger flavours, *e.g.* blackcurrant juice. Indeed, in this connection the high sugar content of swede treacle would be an asset. A blend of the treacle and blackcurrant juice would produce a stable syrup of much greater vitamin C value than the figure of 60 mg. for a straight sugar blackcurrant syrup.

Discussion.

Assuming a reasonable juice yield of 150 gallons per ton of swedes, the yield of treacle of high gravity and vitamin C value should be between 12 and 13 gallons per ton of swedes. Swedes can be easily grown, they are not expensive to produce, and the harvesting period is not short. The treacle once made is stable without the addition of preservatives or sugar. The plant needed for its production—cider-mills and vacuum milk evaporators—is idle when swedes would be available.

It is understood that there is no surplus of swedes at the present time above that required for feeding cattle. Nevertheless, it seems worth considering whether some of the acreage that has produced surplus crops of carrots in the past winters might not be employed to better national purpose in producing more swedes so that a certain tonnage of this vegetable would be available for conversion into vitamin C concentrates for human consumption. The wartime needs for vitamin C have been stressed in so many recent technical publications that it hardly seems necessary to emphasise the point here.

The utilisation of swedes for human feeding would not rob the cattle of the entire vegetable, as the pomace left after juice extraction could be dried like apple or carrot pomace and should provide a valuable concentrated and stable cattle-feed. Whilst most of the sugars are removed in the juice, the nitrogen content is only slightly affected.

This preliminary investigation has not dealt at all fully with the problems that might be encountered in large-scale production, but these first indications are of some interest and further research is being undertaken.

THOSE ACID SOILS MUST BE LIMED.

By A. W. LING, M.Sc., N.D.A.

BERKELEY SQUARE ADVISORY CENTRE.

The Need for Lime.

During the past 18 years the Agricultural Advisory Centre has made a special study of the soils of the West of England and it has repeatedly drawn the attention of farmers to the fact that the liming of acid ("sour") soils should form part of the normal farming programme. Unfortunately, economic conditions since the last war made it impossible for some farmers to undertake the liming of their soils, although they probably realised that their partial crop failures, the low solids in the milk of their cows and their "bad doing" animals, were in some way connected with lime shortage.

Many thousands of soil and herbage samples have been examined at the Advisory Centre for lime content, and these analyses have revealed that in the counties of Gloucester, Hereford, Somerset, Wiltshire and Worcester, slightly over one out of every 10 acres of arable and grassland is deficient in lime to the extent of 1 ton or more of ground limestone per acre. All the older books on farming tell of how our ancestors limed the land, often applying as much as 40 tons per acre. Many farms in the West still possess memorials of this fact in the form of derelict lime kilns and quarries. In any case, this act of good husbandry by previous generations of farmers left in the soil a residue of lime upon which agriculture has been drawing ever since, but this residue is not inexhaustible; in fact, on many farms there is already a serious overdraft. The soil is losing lime all the time. The rate of this loss depends on a number of factors such as rainfall, type of cropping and the soil itself. With regard to the last factor, some soils are, of course, derived from limestone and contain natural supplies of lime, although even with some of these the lime in the surface soil has been leached by rain to such an extent that none remains in the immediate neighbourhood of the plant roots upon which they can draw. Whatever may be the cause, the fact remains that lime is lost from the soil at a rate from 1—4 cwts per acre annually.

Lime for Grassland.

Liming is generally thought of in terms of arable land, but the liming of "sour" grassland is equally important. From the point of view of producing spectacular results on acid grassland, lime is often disappointing when compared with slag, but after all the be all and end all of good farming is not just a mass of wild white clover. Liming acid grassland puts lime into the herbage and that is the only real and proper way of getting lime into the bodies of animals. Moreover, in the process of taking the plough round the farm, some of this acid grassland will come under the plough and in order to obtain a quick rotting down of the turf and to ensure that succeeding crops do not fail a good dressing of lime is essential.

Lime for Arable Land.

There are at least two other outstanding reasons why the land must be limed, and these apply particularly to arable land: firstly, because liming will ensure full crops, and, secondly, because the maximum return must be obtained from the artificial fertilisers which are used on crops. It is not uncommon to hear farmers say that superphosphate or sulphate of ammonia or slag "won't work on my land." In ninety-nine cases out of a hundred

the fertiliser would act if given the proper conditions and, generally speaking, the main reason why the fertiliser does not act or only acts in a half-hearted sort of way is because the lime deficiency of the soil is the limiting factor. This simply means that whatever is done with the soil, or whatever may be put on in the way of artificial fertilisers, will be of little avail until the soil has been limed. It must be remembered that to-day many of our fertilisers depend on shipping and the lives of valiant men are risked to bring them to this country. Therefore not an ounce must be wasted when they get to these shores, and wasted some of them may be if they are applied to acid land and not given the proper conditions to do their work.

Many experiments which have conclusively proved this point have been carried out over a number of years by the Department, but suffice it to quote the results from two. In a barley experiment in Worcestershire, on a light acid sandy soil, where the crop received a dressing of superphosphate and potash but no lime it was a complete failure and it was impossible to harvest anything other than spurrey, whereas where a dressing of ground limestone at the rate of 3 tons per acre was given (the calculated lime deficiency of the soil) in addition to the fertiliser a yield of 2,678 lbs. of grain and straw per acre was obtained. Again, in Herefordshire on a somewhat similar type of acid soil the sugar beet crop, which was completely manured but did not receive lime, yielded $4\frac{1}{2}$ tons washed beet per acre, whereas on the second part which was similarly treated but in addition was limed at the rate of 2 tons of ground limestone per acre, the yield was 16 tons of beet.

The liming of the land, of course, has other well-known advantages. It checks such diseases as finger and toe, inhibits the growth of certain weeds, particularly spurrey, makes conditions in the soil favourable for the growth of beneficial micro-organisms and also tends to make untractable soils more friable.

Testing the Soil for Lime Deficiency.

Whilst there are thousands of acres requiring lime, there are, of course, thousands of acres which do not, and where it would be folly and sheer waste of money to apply it. There is no reason whatsoever why every farmer in this Province and, in fact, in the country as a whole, should be in any doubt as to where lime is needed. If crops such as clovers, sainfoin, lucerne, peas, beans, vetches, barley and sugar beet fail, or are very patchy and yellow in the early stages of growth, lime deficiency should be suspected immediately. Other crops like wheat, roots and ryegrass, may also fail from lime shortage, although they are less susceptible. At any rate, in all these cases a soil test is called for at once. This testing is done free of all cost to the farmer, and it provides him with two valuable pieces of information. Firstly, it will tell him whether or not his soil wants lime, and, secondly, if it does require liming how much per acre and in what form the lime should be applied. County Agricultural Education Staffs and County War Executive Committees are fully aware of the facilities that exist for soil testing and farmers should, in the first instance, contact officers of one of these bodies in order to have their soil sampled in the correct manner for testing. In the case of extreme urgency, the University of Bristol should be approached direct. Incidentally, at the same time as the soil is being tested in the laboratory for lime deficiency it is also examined for phosphate and potash content.

Forms of Lime.

With regard to the forms of lime and their respective values, they may

be divided into three groups :—

- (1) Quick lime and ground lime.
- (2) Slaked lime and hydrated lime.
- (3) Carbonate of lime.

It is difficult to give an accurate statement of their respective values because of impurities in some of the carbonates, but roughly, if a soil is short of lime to the extent of 1 ton per acre, then its degree of acidity may be corrected by applying any of the following :—

- (a) 1 ton quick lime per acre.
- (b) 2 tons ground limestone or chalk per acre.
- (c) 27 cwt. of hydrated lime per acre.

Under war conditions, it is necessary to make more and more use of the various forms of waste limes that are now available, and less of quick lime which is urgently required for other war purposes. The waste limes (these are carbonates with a greater or lesser degree of impurity) are just as good as quicklime in their effect on the soil, provided a sufficient quantity per acre is applied, and are far more pleasant to apply than the latter. In a general way, it is necessary to put on twice or three times the amount per acre of these as compared with quick lime. At the moment there is a fair quantity of these materials available and the amount is likely to increase.

Now that the Land Fertility Scheme in respect of lime has been extended for another four years, limestone crushers should not hesitate in their own and the national interest to put in the necessary equipment in the form of crushing plants to make available to farmers in a suitable form ground limestone and limestone dusts, and farmers on their part should not hesitate for one moment to use these products.

Obviously, the fineness of grinding limestone is important and farmers in purchasing limestone dusts are advised to ascertain that all this dust will pass through the 20-mesh sieve, and 45% or more will pass the 100-mesh sieve. Here again the farmer need be in no doubt as to the suitability of a sample of limestone for application to his land. He can always have the sample examined, free of cost, for fineness of grinding at the University of Bristol.

There are, of course, many other forms of waste limes and limestones available for agricultural purposes and with the development of the sugar beet industry in this country, sugar beet factory waste lime calls for special comment. The partially dried lime material from the Kidderminster factory contains something just short of 60% carbonate of lime, and this material applied at the rate of 3 tons per acre is as good, if not better, than 1 ton of high-grade quick lime. It has the additional advantage over quick lime that it also contains small percentages of nitrogen, phosphates and potash.

The Cost of Liming.

Finally, on the question of cost, under the Land Fertility Scheme whereby the Government pays half, it may be taken that the net amount payable by the farmer is 5/- or 6/- per acre for a dressing equivalent to 1 ton of quick lime. This calculation is based on the fact that the benefit of the initial dressing of lime will last for at least five years and the cost must therefore be rightly spread over that period. It should be mentioned that there is ample evidence in the West Country that the good effects of liming the land persist for ten and even more years.

THE CLEANSING OF MILKING MACHINES.

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During the past few years the installation of milking machines on dairy farms has increased apace. In 1940, a survey of graded milk farms in one area of the Bristol Province showed that, of a total of 240 farms, 38% were using machines. The proportion of machine-users on non-graded farms in this particular area was estimated to be nearly as great. As the area covered by the survey was typical of the rest of the country, and because, speaking generally, machines are naturally confined to the larger dairy farms, it is reasonable to conclude that well nigh half the entire milk output of the whole country is now produced by machines of one type or another.

The general care and cleansing of machines, therefore, assumes increasing importance, especially when it is appreciated that the wholesomeness, or bacteriological quality of machine-produced milk depends to a very great extent on the degree of cleansing and care of operation of the machine itself. This raises the pertinent question so often asked by farmers contemplating the installation of milking machines, namely, is it possible to produce as pure a milk supply by machine as by hand? The answer to that question is quite definitely in the affirmative, providing—and only providing—that (1) the machine is operated competently and (2) that it is cleansed thoroughly. On the other hand, failure to exercise meticulous care with one or other of those processes will inevitably bring disappointing results. Proof of this fact comes daily to the writer's notice in the form of milk samples of extremely high bacterial content and correspondingly poor keeping quality from machine-milked herds.

Speaking generally, the experiences of the Dairy Bacteriological Department at this centre is that from the aspect of clean milk production the operation of the machine on many farms is usually good, but often the cleansing of the plant is extremely bad. In many such cases the machine is not properly cleansed simply because the dairy workers do not appreciate the significance of the detailed methods that must be employed to render the machine in a fit condition for clean milk production. With the increasing scarcity of skilled dairy workers this fact becomes more and more serious, and if the losses of milk incurred during last summer are to be avoided this year, far greater attention must be paid to the proper cleansing of milking machines in particular and, of course, to dairy equipment in general.

Cleansing.

The term cleansing means (a) the removal of all dirt and residues and (b), the destruction of virtually all bacteria on the parts of the plant with which the milk comes in direct or indirect contact. In other words, cleansing implies thorough physical washing and adequate sterilization. There is no short road to success; the washing and the sterilization are equally important and both processes must be accomplished with due thoroughness. Special attention to one process will not fully compensate for any slackness in other respects, and it is of little avail to cleanse thoroughly, say, the metal pipe-lines unless the rubber parts are treated likewise, and *vice-versa*.

The removal of visible dirt and foreign material from the milking units and pipe-lines is accomplished by two distinct operations, each having a definite object.

The first consists of a preliminary cold water rinse to remove the milk solids, particularly the curd, which if not removed from the internal surfaces of milk tubes and pipe-lines produces a film when it dries, and forms hard milk scale when hot water or steam is applied. Once milk scale is allowed to become established it is extremely difficult to remove, and its presence renders effective sterilization impossible. Undoubtedly the preliminary cold water rinse is the fundamental secret of a bacteriologically clean machine. Yet in practice this operation is often neglected, possibly because of its mere simplicity. The full benefit of the preliminary rinse can only be secured when (a) the cold water is flushed through the system immediately milking is finished so that the milk has no time to dry on the interior surfaces and (b) when a sufficient volume of water—at least one gallon, and preferably two—is drawn through each unit.

Cold water will not remove the milk fat which adheres readily to rubber and metal surfaces, hence the need for the second operation, namely, thorough washing, scrubbing and brushing, with hot water to which a little detergent has been added. Effective washing can be accomplished with hot water alone, but more time must be spent and more water used. Therefore the use of $\frac{1}{2}\%$ soda solution, or a reputable detergent solution in the strength recommended, is strongly advised, especially when the dairy water supply is hard. After washing with the detergent it is important that the machine be given a final hot water rinse prior to sterilization.

Sterilization. Steam or hot water treatment at 210°F. is the best means of sterilization for dairy farm practice. When exposed for 20 minutes at that temperature all vegetative forms of bacteria are destroyed; only the more heat-resistant sporing bacteria will survive. These should not be numerous in the milking machine system provided the preliminary rinse and detergent wash have been thoroughly done. Therefore if the machine can be dismantled and steamed in a chest, sterilization will destroy 99.9% of the bacteria present.

There is ample evidence to show that jet-steaming of teat-cup clusters at 210°F. for 4 minutes is satisfactory for all practical purposes. For bails and combine milkers, where sterilization is effected by passing steam through the assembled plant it is necessary to prolong the steaming for at least 15 minutes after the teat-cups of the milking unit remote from the boiler are too hot to touch. If the steam supply is insufficient to allow the temperature to be maintained for that period of time it is advisable to double-steam for two shorter periods.

Farmers often object to the rigid steaming advised on the grounds that it causes rapid deterioration of the machine rubbers. In this connection it is interesting to record that research work in progress at the National Institute for Research in Dairying tends to show that the short life of rubbers is not due to the direct effect of steaming but more probably to the absorption of water and, more especially, of fat into the rubber itself. These findings lay increased emphasis on the quick and effective removal of the milk fat from rubber surfaces by thorough washing with hot detergent solution.

Chemical Treatment. Owing to possible scarcity of fuel supplies for

steam raising, it may be necessary to resort to the use of disinfectants for sterilizing purposes. It should be mentioned that as the law exists at the moment, milking machines are the only dairy equipment that may be sterilized by chemical means.

Although chemical sterilization has been practised in America for a number of years it has not found favour in this country, probably because steam is so convenient and since the chemical solution must be prepared accurately to produce the maximum effect. Hypochlorite solutions are suitable for the purpose and should be mixed so as to contain 300 parts per million of available chlorine; also it is very desirable to add a trace of alkali, such as $\frac{1}{4}\%$ carbonate of soda. If proprietary hypochlorite products are used, the instructions regarding the mixing should be carefully followed.

The sterilizing treatment can be carried out either by immersing the parts of the machine in a tank containing the solution or by drawing the solution through the assembled plant. In the former case care must be taken to avoid air-locks, and in the latter, sufficient volume of the disinfectant must be drawn through the plant to ensure that all parts of the interior surface are wetted. The chemical must be left in contact with the surfaces to be sterilized for at least 4 minutes. Finally, the machine must be rinsed with pure water and drained prior to use.

The evidence available suggests that in actual farm practice chemical treatment may not give such a high degree of sterility as steaming, therefore it is advised only when steam sterilization is impracticable. If applied to economise fuel it is suggested that the machine should be taken apart and given a thorough steaming once a week.

Thus good, clean, wholesome milk can be produced where proper attention along the lines indicated is paid to the machine and all its parts, and farmers should not be deterred from installing a machine merely by the thought that the hygienic quality of milk may suffer.

THE CONTROL OF ANIMAL DISEASE. MASTITIS OF DAIRY CATTLE.

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A great deal of time has been spent in the past year on routine diagnosis, but the specimens so examined from individual animals have furnished valuable information essential for the control of disease, not only in the individual, but also in the herd or flock. Last year the writer stressed the great assistance which blood agglutination tests can be in the control of Contagious Bovine Abortion and this type of work has been continued and will doubtless develop. Bacteriological examination of milk for the presence of mastitis organisms is a necessary adjunct for the proper control of this disease in a dairy herd, but before discussing control measures it is of interest and importance to give some account of the causes and symptoms of this disease.

Nature of the Disease.

Mastitis is an inflammatory condition of one or more quarters of the udder and is responsible for much of the financial loss which the dairy farmer has to face in respect of diseases. It would be no simple matter to estimate with any degree of accuracy the reduction of the milk yield from herds in any given area as a direct result of this condition, and there are other factors which tend to increase the loss, such as the deleterious effect on the animals themselves resulting in depreciation in value and in some cases death. It is distinctly more prevalent in cows five to six years old, which means that the effects are more in evidence at a time when the milk production of the animal is approaching its maximum.

Throughout the world herds which are entirely free from garget are unfortunately the exception rather than the rule. The disease is due to microbes setting up an inflammation of the udder, the severity of the symptoms shown by the affected animal depending upon the virulence of the microbe responsible, and, of course, the constitution of the cow. The organisms found are very variable in character, but streptococci predominate in cases met with in this country.

The way in which the condition spreads is in many cases a mystery. At the ends of the teats of a milch cow will usually be found a droplet of milk and the microbes are said to be carried there by flies, by contact with floors, from the milking machine and even by the milker's hands. It has been suggested that some cases are caused by organisms invading the bloodstream from a septic focus in the womb settling in the udder and carrying on a similar process there. Still less is known about the spread of Summer Mastitis which may affect dry cows or heifers and in some parts of the country is a very serious problem to many farmers, some of whom report good results from dressing the teats with Archangel-tar as a preventive.

The symptoms of the disease will be well known. The acute type is characterised by its sudden onset; an animal will be found in the morning with a quarter enlarged, red and painful. The hind legs will probably be straddled. The teat is swollen and stiff and evidence of pain is shown when

it is milked. In many cases the teat is so swollen that the milk canal is closed and no milk can be brought through. Should some milk be drawn, it first may appear fairly normal, then yellowish to dark brown or even having a reddish tint with an unpleasant odour. The chronic type may only be evidenced by occasional clots in the milk which will be seen by the observant milker, and the milk will probably be of a poor keeping quality.

The sequel to an attack of the acute type may be abscess formation with a chronic suppurating discharge. Gangrene may set in and the affected quarter slough off. In some cases, which are unfortunately rare, the symptoms appear to abate in 2—3 days and milk secretion begins once more.

The forms in which garget exists on farms vary considerably. In some cases all that is encountered is an occasional cow showing symptoms of the acute form of the disease already described. Treatment on the usual lines is adopted with perhaps success and nothing more is done. The cure, however, may not be so complete as it would appear on examining the cow. Many animals continue to harbour the causal microbes in the udder, become chronic cases or "carriers," and as such are a source of danger to other cows. There is also the likelihood of the disease re-appearing when the resistance of the animal is lowered by being out in rough weather or at calving. The usual history of these "carriers" is thus a series of acute attacks gradually destroying the milk secreting tissue of the quarter or quarters affected until eventually these portions are rendered functionless and atrophied.

Preventive Measures.

It is, unfortunately, impossible to recommend a system which will make certain that no cases of garget will occur on a farm, but certain measures can be taken to reduce the risk of any outbreak. As a routine, the farmer should maintain a strict standard of cleanliness in the housing and milking of his cows. The provision of clean cloths for wiping udders and cleanliness of the milkers' hands is essential, or if a milking machine is used, careful sterilization of the component parts after each milking. No cows approaching the end of their lactation should be dried off too quickly. Any injuries which occur on the udder or teats should be treated with great care, as these may develop into garget.

If a case of the disease does occur it should be borne in mind that the condition is infectious and measures should be taken to avoid spread to healthy cows. At the present time much work is being done by infusing the affected quarter with drugs which have been found effective in killing the organisms responsible. Drugs which have given good results in human medicine for various inflammatory conditions are also being extensively used in cattle, and as they are given by the mouth, the farmer himself can administer the necessary dose at frequent intervals.

Whatever treatment is adopted, frequent stripping of the affected quarter or quarters is an essential adjunct and the stripping should be done into a tin of disinfectant in order to prevent any contamination of the bedding or the floor. Isolation of the affected animal is desirable or it may be placed at one end of the cowshed and milked last, and if stripped frequently the milker should wash his hands after each operation. Thus with care the risk of spread is reduced to a minimum.

Eradication.

To free a herd from mastitis it is necessary to find the "carrier" cows, which are infected though they may not show any clinical symptoms. There are a number of tests which can be applied by the farmer himself to assist in the detection of these animals, *e.g.* strip cup test, brom cresol test, but in order to get a reasonable degree of success in detecting "carriers," bacteriological examination of the milk from each cow is necessary. Having found the infected animals, they should be placed at one end of the byre and milked after the healthy animals, which are placed at the other end of the byre. A close watch should be kept on all the cows in order to detect cases in the early stages to ensure that treatment is administered without delay. Infusion of the udder when the cows are dry appears up to the present to give a higher proportion of cures, and this method of treatment is popular with farmers, as it causes less disturbance in the usual routine, and there is no risk of drop in milk yield with such animals. By applying curative measures to the infected cows which perhaps have only one quarter involved, and the weeding out of animals which are badly infected and obviously not likely to pay their way, a mastitis-free herd may be built up. This process is bound to take a little time, but the farmer will be going a long way towards accomplishment if he keeps a close watch on his herd, isolates his infected or "carrier" animals in the cowshed, and applies remedial measures as early as possible after an acute attack is observed. In this way he will not only be safeguarding his own interests, but also increasing the supply of marketable milk in this country.

A REVIEW OF THE WORK IN AGRICULTURAL ECONOMICS.

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The programme of work has remained largely upon previous lines, and although in the first half of the year the work was somewhat interrupted by changes in staff, it has now resumed its normal course.

National Farm Survey.

There has, however, been a considerable addition to the work in the Economics Section, due to the fact that Advisory Economists are taking part in the National Farm Survey, by which it is hoped to obtain a great deal of useful information relating to all farms in England and Wales of 5 acres and above. Up to the time of writing this work is only just beginning. The staffs of the County War Executive Committees are engaged in the actual work of visiting the farms and completing the survey schedule. It is the task of the Economist to check the schedules for completeness and accuracy and to file them with the 4th June Returns. It is anticipated that the Survey will bring to light a number of farms where the 4th June Return is not accurate, also a number of farms from which no Return has ever been received. All farms are to have their boundaries delineated either upon 6" maps, or 25" maps reduced to 12½"; the task of mapping is solely the responsibility of the County Staffs, but the maps when complete are to be placed in the custody of the Economist.

The records are to be subjected to machine analysis and tabulation. Although the survey is primarily for national purposes, all the data relating to the Bristol Province will be available for local advisory and research purposes and should prove to be of very great value.

Farm Management Survey.

General. In connection with other investigations, a study has been made of the ways in which farm management has been modified during the transition from peace to war. For this purpose it has been possible to examine the quantitative and financial data for 135 farms for each of the three years 1938/9, 1939/40, and 1940/41. The total acreage of these farms, excluding farm buildings and roads, is between 36,000 and 37,000 acres. In the first two years, less than one-quarter of the land was under arable crops, but in the third year, largely on account of the ploughing-up policy, the proportion had increased to nearly one-third. During the three years the acreage of wheat on these farms rose only slightly, although the country as a whole showed a considerable increase; barley, however, increased by 50% and the oat acreage was doubled. In the first two years the acreage under mixed corn was practically nothing, but in the third year 348 acres were grown. Sugar beet covered only two-thirds of its pre-war acreage, but potatoes increased by approximately a third. The total acreage mown for hay in the third year increased by over 10%. During the three years only 41 acres of corn and 52 acres of roots failed. Of the corn crops 94% of the wheat, 74% of the barley and 35% of the oats were sold.

Seeds and Fertilisers. As was to be expected, the seeds bill per acre has been almost doubled and at the same time the arable acreage has increased from 8,500 to 11,000 acres.

Of the 135 farms under review, 99 purchased fertilisers in the first year and 107 in the third year. Thus, even in the second year of the war, one-fifth of the farms were not receiving an application of artificials. This is probably due to the restricted supply of phosphates, particularly for permanent grassland. On the other hand it is noteworthy that the war has had the effect of doubling the pre-war outlay on fertilisers. Allowing for the increased prices the net result is that farmers to-day are applying roughly $1\frac{1}{2}$ cwt. for every 1 cwt. they applied in pre-war days.

Livestock. In livestock farming, the dairy herd has been well maintained throughout the period. There has been a slight change in the distribution of the herd as between cows and heifers. During the period there has been a rise in the number of cows in milk and in calf concurrently with a decline in the number of heifers in calf. Other cattle declined in the middle year, but at the end of the third year were higher than at the beginning of the period. The total number of all classes of cattle has also risen slightly. The values of cows and heifers showed no appreciable increase per head until the closing values of 1941. There has not been such a great turnover in cattle during the period; both purchases and sales have fallen consistently.

There has been little decline in dairying. The total gallons produced have fallen by only 7% over the three years, while the number of farms selling milk has risen slightly. The daily yield has declined from $1\frac{2}{3}$ gallons to $1\frac{1}{2}$ gallons per cow in the herd.

In sheep farming, the ewe flock, which actually increased in the first two years, declined by one-fifth by the end of the third year. On the other hand the numbers of other sheep were maintained. Of the 135 farms under review, only 77 were keeping sheep at the end of the period as compared with 83 at the commencement.

In the case of pigs, both the numbers of sows and of other classes have fallen considerably. While 99 farmers were keeping pigs at the beginning of the period there were only 87 at the end.

Poultry increased considerably in the first two years, but in the last year the numbers had fallen from 28,000 to 20,000.

Horses have declined consistently.

A study of the purchases and sales is interesting. In sheep farming purchases were fairly well maintained, but sales were halved. An examination of the figures of sales of fat lambs and fat sheep gives one the impression that farmers, foreseeing the difficulties of maintaining their flocks, fattened and disposed of their lambs as soon as possible, so that the considerable increase in the number of fat lambs sold is largely at the expense of sheep over six months old. This disposal was encouraged by the instructions of the Ministry of Agriculture to curtail the grassland flocks.

Sales of wool increased from 62,000 to 71,000 lbs.

The position of store pigs is almost the reverse of that of store sheep. The purchases of stores declined from 9,000 to 7,200, but the sales, far from declining, actually increased slightly over the period. The sales of baconers

also increased slightly, probably due to the considerable rise in price. On the other hand the sale of porkers has been halved during the period in spite of greatly increased prices. The net result is that with the decline in the total number of pigs purchased, and the heavy decline in the number of pigs carried on the farms, the total numbers sold have been well maintained. The obvious inference is that farmers have been selling out of pigs as rapidly as possible.

Purchases of poultry declined somewhat over the period, and sales were fairly well maintained, but, as with pigs, the numbers carried have declined. The sales of eggs have been well maintained; the average price received per dozen increased by 40%, and there is no doubt that farmers, although faced with a shortage of purchased feeding-stuffs, surmounted other difficulties by retaining the heavier-yielding breeds. It is also interesting to note that while 86 farms were keeping poultry at the beginning of the period, 93 were carrying flocks by the end of the third year.

Feeding Stuffs. Feeding stuffs have risen in price as the war has progressed. Despite the curtailment of supplies under the rationing scheme, the total amount spent has increased from £112,000 to £132,600.

Rentals. The aggregate gross rent on these 135 farms amounted to approximately £50,000. Cottage rents received plus the rental value of the farmhouses reduce this figure to £44,000, which is equivalent to a net rental of 23s. 9d. per acre.

Implements and Machinery. Roughly £600 per farm is invested in implements and equipment. It is interesting to note that at the beginning of the war there were 71 tractors on 58 of these 135 farms, but by the end of the three years there were 114 tractors on 84 farms or one tractor to every 97 acres of arable land.

While there has been little machinery and equipment sold, the extent of purchases of new machinery is very considerable; partly due to increased prices of new equipment, but more probably due to additional equipment being required for the increased area of arable land under the ploughing up policy. Thus, while approximately £13,000 was spent on new machinery in the first year, over £20,000 was spent in the third year. Similarly, the bills for repairs and fuel are very considerable. The cost of repairs rose from nearly £12,000 in the first year to £14,000 in the third year, while the fuel bill increased from £7,500 to something over £12,000.

The mechanical side of farming is placed in clearer perspective when these figures are calculated on an acreage basis. In running a farm it is not so much the amount of capital invested in implements that matters, as the amount of depreciation on such equipment per acre. On these farms this depreciation amounted to 6s. 11d. per acre. Similarly, the cost of repairs amounted to 7s. 7d. and the fuel to 6s. 7d., so that what may be termed the current costs of equipment amounted to approximately one guinea per acre.

Miscellaneous. Before dealing with the question of farm labour there are a few miscellaneous items of expenditure and income which call for reference. Of these, the most interesting is the expenditure on medicines and veterinary services. Roughly speaking the bill has remained the same over the three years at about £2,200 per annum, equivalent to £16 or £17 per farm each year.

On the income side, it is interesting to note that the value of farm produce consumed in the farmhouse amounted to approximately £30 per farm per annum.

The ploughing subsidy, which was just beginning to interest farmers in the first year, rose to nearly £1,000 in the second year, and to nearly £3,000 in the third year.

The remaining miscellaneous income consists of a large number of sundry items which together amounted in the third year to about £4,500.

Labour. Before concluding the analysis of farm expenditure the very important factor of labour must be examined. One striking fact is that the numbers of regular men workers increased during the period from 658 to 679, and while the number of boys decreased from 76 to 67, the number of women workers increased from 26 to 40. So far as these farms are concerned, therefore, the problem of labour scarcity has not been of much importance. It is noteworthy that the cash wages of men increased during the three years by £17,000 on £67,000, namely by approximately 25%. There was a slight increase in the total cash wages to men in the second year, but by far the greater increase occurred in the third year when the minimum rate moved from around 36s. 0d. to 48s. 0d. per week; but the full effect of this increase was not felt even in the third year.

In addition to cash wages there are, of course, wages in kind, which comprise free cottages, board and lodging and other perquisites such as free milk. It is interesting to note that despite the increase in wages, the number of free cottages on the 135 farms increased from 173 to 200. The total value of wages in kind increased from £2,100 in the first year to £2,500 in the third year. While in the first two years the value of wages in kind to boys and women were almost negligible, there was a very considerable increase in the third year; this is largely due to a greater number of these workers being boarded in the farmhouse.

It is not possible to give here details relating to casual labour, but there was a considerable increase in casual wages in the third year. In addition to the total of wages either in cash or in kind, it must not be overlooked that the total labour cost to the farmer includes the cost of insurances which have to be borne by the employer, such as the Employers' Liability Insurance, and the employers' share of the National Unemployment and Health Insurance contributions.

In assessing the total labour cost on these farms a distinction is drawn between wages paid to employees and the wage-value of the manual work performed by the farmers themselves and their sons. The importance of such unpaid manual work may be judged from the fact that on the 135 farms under review, there was the equivalent of 127 full-time men and their wage value was over £17,000 in the third year. This does not mean that 127 out of the 135 farmers are full-time manual workers since a considerable amount of unpaid work is performed by the farmers' sons. On two of the farms there were no regular paid workers; the two farmers themselves managed the farms with the assistance of some casual labour.

Contract work assumed a much greater significance as was to be expected. Work done on these 135 farms by outside contractors increased in value from £868 to £2,738, while on the other hand these farmers in turn performed work

for other farmers which in the aggregate rose from £978 to £2,293 over the three years.

For the sake of clarity the total labour cost on these farms is given in tabular form below for the first and third years :—

Aggregates.	Year 1938/9.	Year 1940/41.
	£	£
Paid Regular Labour	74,506	92,845
Paid Casual Labour	3,089	3,542
Insurances	3,003	3,168
Total Paid Labour	80,598	99,555
Contract Work (net)	— 110	+ 445
	80,488	100,000
Value of Unpaid Labour (Farmers and Their Sons)	15,165	17,227
Total Farm Labour Cost	95,653	117,227

In examining any industry it is not so much the total cost of labour that matters, as the relative cost. In the present case, owing to the considerable ^{app.} increase in receipts, the proportion of the income absorbed by labour has fallen over the three years from 23½% to 20½%, and, in spite of the increase in wages per man, as referred to above, the proportion of the total expenditure absorbed by labour has remained identical, since total expenditure also increased.

In drawing to a conclusion this analysis of the transition from peace to war, the whole financial position on these 135 farms can be briefly summarised. Net profits rose from approximately £11,000 in the first year to nearly £97,000 in the second, and to nearly £122,000 in the third year, with the result that, taking the period as a whole, these 135 farms made a total net profit of approximately £230,000. The position is even better than this since, although there has been charged in these accounts the value of the manual work performed by the farmers themselves and by their sons, such an expense would not be allowed as an ordinary accounting method. The total value of such farmers' labour amounted, for the whole period, to something over £47,000, and this amount, when added to the profit just stated, brings the grand total of net profits to something over £277,000 or to approximately £2,052 per farm.

The total is comprised of a profit of £192 per farm in 1938/9 ; of £830 in 1939/40, and of £1,030 in 1940/41.

At first sight the increase in the profits in the last two years seems excessive, but it must be remembered that for a long period of years the whole agricultural industry was in a very depressed state. For instance, in the first three years under review the net profit of £192 per farm yields less than £4 per week to the farmer for the risks taken, and the manual labour performed either by himself or members of his family. If the whole of the profit for that year be calculated as a return on the capital invested it amounts to something under 7%, and in view of the admittedly high risks in agriculture this return can only be regarded as being far below the return that would be expected in urban industry. Even this rate will be halved if the capital invested in land

and buildings is reckoned as comprising part of the productive capital invested in the agricultural industry.

The average farm in this inquiry covers approximately 270 acres, so that the profit in the first year amounted to only 14/4 per acre. In the two subsequent years the profit has increased to 60/6 and 75/9 respectively, and the return on capital has correspondingly moved to 27.6% and 31.4%, but these higher profits must be placed in relationship to the much lower returns obtaining in the years of depression, if they are to fall into correct perspective.

These wartime profits are in themselves an indication of the efforts farmers are making to increase the country's food supply. There is a widespread feeling that part of this increased output of food is being obtained only by depleting the soil of some of its fertility. This danger has been recognised by modifying the ploughing up policy so as to give farmers more latitude in the types of crops which may be grown. It is too early yet to say to what extent this conversion of a capital asset into an item of current expenditure has occurred, and therefore to what extent reparation would have to be made in the post-war period. Obviously the country requires maximum food output during the war, but it is equally obvious that this maximum can only be consistently maintained for the duration of the war, however long that may be, if the rules of good husbandry are followed in war no less than in peace.

REPORT ON ADVISORY WORK, 1940-1941.

The period covered by this report has witnessed a further intensification of the food production campaign, which has necessarily brought in its train numerous technical problems for the Advisory Service. All the Advisory Officers and a number of the Research Station personnel have been called upon to assist in special schemes of the Ministry and to serve upon Technical Committees. In addition to these activities enquiries from County War Agricultural Executive Committees, County Agricultural Education Committees, farmers and the members of the general public have continued to increase during the year and the total number of requests for advice has reached a new high record.

Working conditions, both at Berkeley Square and Long Ashton were difficult during the winter months of 1940-1941 owing to the severe air raids, but by improvising in many ways work was continued without any serious break. The labour situation has raised difficult problems regarding assistants, but so far these have been surmounted.

The number of enquiries shown in the statistics for 1941, which are directly comparable with 1940, shows an increase of 677. This comparison makes allowance for the omission of statistics for Poultry Pathology and the inclusion of records for Willows in 1941.

The main features in the totals accounting for the change are substantial increases in Agriculture and Agricultural Chemistry (+ 286), Veterinary Science (+ 137), Pomology and Vegetable Culture (+ 92), Economic Entomology (+ 107). The only appreciable decreases are for Cider (- 83) and Cider Instruction (- 32), the latter being due to the falling out of Dorset from the Scheme in March 1941.

It will be noted in the report of the Veterinary Investigation Officer that he has continued to deal with advisory problems relating to Poultry Pathology.

A feature of the work in Agricultural Economics has been the inauguration of the National Farm Survey, the Economist being responsible for the checking and filing of returns of all farms in the Province.

Survey work under the Land Fertility Scheme has been continued in the Agricultural Chemistry Section and the Special Wire Worm Investigations have been continued in the Entomological Section.

The Research Entomologist has rendered valuable services to the Public Health Authorities in Bristol in connection with the control of pests on food-stuffs and in air raid shelters and buildings following air raids.

The Department has co-operated with the Ministry in its schemes of Fruit Preservation carried out through the Women's Institutes.

Much help has been given by the Plantations Officer in connection with the Food Production Campaign in Bristol, and demonstration plots have been established on allotments at five centres in the city area.

During the year there has been a revival of interest in Willow Growing and forty-five enquiries were received. These were dealt with by the Research Entomologist who has had considerable experience with the crop.

The Advisory work in the present report is classified under the following headings:—Agriculture and Agricultural Chemistry, Dairy Bacteriology, Agricultural Economics, Veterinary Science, Cider, Cider Instruction, Fruit Products, Pomology and Vegetable Culture, Horticultural Chemistry, Economic Entomology, Economic Mycology, Insecticides and Fungicides, Domestic Preservation of Fruit and Vegetables, and Willows. Statistics refer to thirteen subjects, three at Berkeley Square and ten at Long Ashton.

The number of enquiries submitted to the Department during the past six years is summarised in the following table:—

	Year ending September 30th.					
	1936	1937	1938	1939	1940	1941
Gloucester (including Bristol)	1622	1730	1775	2264	1965	2491
Hereford	497	275	337	556	182	196
Somerset	1138	1118	1459	1117	1403	1479
Wiltshire	848	1007	1328	1586	970	1410
Worcester	509	360	520	677	656	1010
Other Areas	1872	1963	1813	1516	2686	1776
	6486	6453	7232	7716	7862	8362

The figures are shown separately in the table for the five centres which comprise the Bristol Advisory Province and for Other Areas. The latter category includes Devon and Monmouth, both of which contribute annual grants to the Long Ashton Institute, and Dorset, which participated in the Cider Instruction Scheme until March 1941.

Staff Changes and Appointments.

Agriculture and Agricultural Chemistry.

Mr. E. L. Smith, B.Sc., was transferred from the Land Fertility Scheme as Assistant Advisory Chemist vice Mr. H. T. Watkins, M.Sc., resigned. Further changes under the Land Fertility Scheme were as follows:—

Appointments:—Mr. W. J. Cook, Fieldman; Miss W. Greenfield and Miss W. F. G. Smallwood, Assistant Fieldmen; Miss M. P. English and Mr. G. A. Gray, Analysts.

Resignations:—Mr. R. O. Easdown, Mr. W. Metcalfe, Mr. J. M. Adams, Fieldmen.

Agricultural Economics.

Appointments:—Mr. W. J. Hewitt, B.A., transferred from Advisory Economics to Supervisor, Farm Survey; Mr. L. M. Marshall, N.D.A., Miss E. Alder, Mrs. K. Sherwood as Records, Farm Survey; Mr. L. Hirschberg, Eng. Agr. (Ghent); Mr. M. Nussbaum, B.A., Miss T. M. Beynon, B.Sc., as Technical Assistants, Advisory Economics.

Resignations:—Mr. E. Dawson, B.Sc., Student Assistant, and Mr. H. J. Steer, B.Sc., Technical Assistant.

Economic Entomology.

Appointments:—Mr. S. H. Bennett, B.Sc., transferred from Wireworm

Survey to become Assistant Entomologist ; Mr. L. E. W. Stone, B.Sc., Mr. A. J. Lloyd, B.Sc., and Mr. C. H. Hoddell, as Fieldmen, Wireworm Survey ; Mr. A. Stringer, B.Sc., Analyst, Wireworm Survey ; Mr. N. G. Morgan, B.Sc., Assistant Mole Destruction Grant.

Resignations :—Mr. A. J. Lloyd, Fieldman, Wireworm Survey.

Fruit Products.

Appointments :—Mr. I. Glazewski, Chemical Assistant, Special Scheme for Black Currant Juice Manufacture.

Fruit and Vegetable Preservation.

Appointments :—Miss M. Jones, Dip.Hort. (Studley), Miss D. P. Jones, B.Sc. (Dom.Sc.), as Assistants. Miss M. Jones seconded for duty to Ministry of Agriculture from 4th June, 1941. Miss E. Kirkby, temporary appointment from 22nd January, 1941, to 4th June, 1941.

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